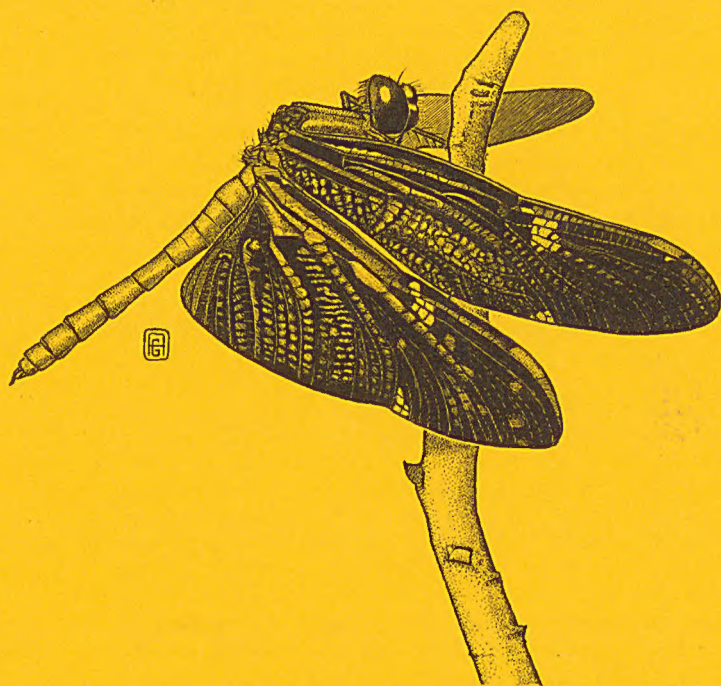


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Cover: A basking male of *Rhyothemis princeps princeps* Kirby 1894 (Odonata: Libellulidae) at Eubenangee Swamp, North Queensland. This subspecies occurs in tropical Queensland from Rockhampton north to Iron Range and Weipa and is also known from southern New Guinea. It is very common at most standing waters in the Queensland Wet Tropics where it occurs together with its congeners *Rhyothemis graphiptera* Rambur, 1842 and the rarer *Rhyothemis resplendens* Selys, 1878. Another race with much more extensive hyaline areas occurs in north and east New Guinea. Pen and ink drawing by Dr Albert Orr whose illustrated books on dragonflies and butterflies have won awards in Australia and overseas. He lived at Bramston Beach 1999-2004 and nearby Eubenangee Swamp was a favourite hunting ground.

THE DISTRIBUTION OF *EUPLOEA DARCHIA NIVEATA* (BUTLER, 1875) (LEPIDOPTERA: NYMPHALIDAE: DANAINAE) IN TORRES STRAIT, QUEENSLAND, AUSTRALIA

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Abstract

A review of the known distribution of *Euploea darchia niveata* (Butler) showed that the taxon predominately occurs on mainland Queensland but also encompasses Thursday (Waiben) Island in the very south of Torres Strait. Based on this review, the record of a single female collected on Darnley (Erub) Island, Torres Strait in April 1910 by Hermann Elgner seems unusual. Despite Elgner's generally high standard in the veracity of his specimen labelling, this particular record is considered to be erroneous. Based on a reconstruction of Elgner's 1910 travels through Torres Strait by using data from specimen labels, a probable explanation for this record is that the specimen was collected on Thursday Island around 29 March 1910, prior to his departure for Darnley Island. On reaching Darnley on 3 April 1910 the specimen was then likely mistakenly labelled as originating from Darnley Island. The suggested narrower range of this taxon highlights the Australian endemic status of *E. d. niveata*.

Introduction

The crow butterfly *Euploea darchia* (W.S. Macleay, 1826) is known from Timor, Banda, Aru and the Kai Islands and northern Australia (Ackery and Vane-Wright 1984, Morishita 1985, Braby 2000). Two endemic subspecies occur within Australian limits. *Euploea d. darchia* is known from coastal Northern Territory including Gove Peninsula (Braby 2000 and pers. comm.) and from the Kimberley area of Western Australia (Braby 2000). *Euploea d. niveata* (Butler, 1875) is recorded predominately from coastal areas of northern Queensland (Braby 2000), where it is known from Thursday (Waiben) Island in Torres Strait south through Cape York Peninsula, including its west coast bordering the Gulf of Carpentaria to Weipa (McCubbin 1971) and Kowanyama (Hopkinson 2011), then south along the east coast to Mission Beach (Braby 2000) and Tully. South of the Wet Tropics, *E. d. niveata* has been recorded sporadically (possibly as vagrants) from Murray Upper (recorded here), Mackay, St Lawrence, Yeppoon, Caloundra, Brisbane and Burleigh Heads (Common and Waterhouse 1981, Braby 2000, Moss 2010, A.G. Orr pers. comm.).

Euploea d. niveata frequents a variety of wet shady habitats, including rainforest, monsoonal vine forest and wet coastal swamps (Barrett and Burns 1951, McCubbin 1971, Braby 2000). Although generally uncommon and erratic in its distribution, it is observed more frequently in the very north of its range, for example at Bamaga and Lockerbie at the tip of Cape York Peninsula and on Thursday Island.

While *E. d. niveata* is known essentially from the Queensland mainland, with records from the south of Torres Strait (Waterhouse and Lyell 1914, Lambkin

and Knight 1983, De Baar 1988, T.A. Lambkin unpublished data), there is a longstanding and puzzling isolated record, documented in Waterhouse and Lyell (1914), of the butterfly's occurrence on Darnley (Erub) Island, Torres Strait, a substantial distance across water (approximately 200 km) from Thursday Island and Cape York. In this paper I discuss a likely hypothesis that would account for this record, which in all probability is incorrect, and outline the species' ostensibly restricted distribution in Torres Strait.

Abbreviations of collectors' names or collection repositories are: AIK – A.I. Knight; AM – Australian Museum, Sydney; HE – H. Elgner; MDB – M. De Baar; QDAFFC – Queensland Department of Agriculture, Fisheries and Forestry collection, Brisbane; TAL – T.A. Lambkin; TLIKC – Joint collection of T.A. Lambkin and A.I. Knight, Brisbane.

Material examined

Specimen under review

QUEENSLAND: 1 ♀, Darnley Island, 13.iv.1910 [HE] (AM) (recorded as *E. hyems niveata* [Butler] in Waterhouse and Lyell 1914, p. 23) (Fig. 1).

Additional material examined

QUEENSLAND: 3 ♀♀, Green Hill, Thursday Island, 2.v.1989, 12-15.iv.1992, 3.iii.2004, AIK (TLIKC); 2 ♂♂, 1 ♀, same data except 27-29.iii.1987, MDB (TLIKC); 1 ♂, 1 ♀, same data except 9.iii.2001 (♂), 12.i.1994 (♀), TAL (TLIKC); 1 ♂, Lockerbie Scrub, 14 km NE of Bamaga, 23-31.vii.1983, TAL (TLIKC); 1 ♂, 2 ♀♀, same data except, 21-24.vi.1992, AIK (TLIKC); 2 ♂♂, 17-21 km NE of Bamaga, 3-8.v.1994, AIK (TLIKC); 2 ♂♂, 20 km E of Bamaga, 27.vii.1983, AIK (QDAFFC); 1 ♀, Cape Tribulation, 10.v.1979, TAL (TLIKC); 1 ♂, Kuranda, 21.iii.1975, MDB (TLIKC); 1 ♂, Cairns, 22.v.1982, TAL (QDAFFC); 1 ♂, Flying Fish Point, via Innisfail, 4.v.1978, TAL (TLIKC); 1 ♂, Coquette Point, via Innisfail, 20.iv.1987, TAL (TLIKC); 1 ♂, same data except, 22.iv.1987, AIK (QDAFFC); 1 ♀, El Arish, 19.iii.1975, MDB (TLIKC); 1 ♀, Tully, 22.iv.1982, AIK (QDAFFC); 1 ♂, Murray Upper, 15.ii.1989, MDB (TLIKC); 1 ♀, Burleigh Heads, 9.iv.1977, TAL (TLIKC).

Discussion

Euploea darchia niveata (Butler, 1875) was described (as a subspecies of *Calliploea darchia*) from material (in the original description) from 'Queensland' and 'Australia' (Edwards *et al.* 2001). In a later publication, Butler (1878) recorded a male from Cape York and a female from Fitzroy Island, Queensland as types but Edwards *et al.* (2001) considered that these locations could have been from subsequent accessions to the material used in the original description. In any case, Waterhouse and Lyell (1914) listed several localities for the butterfly, stretching from Cape York south to Mackay on the mainland, with additional records from Thursday and Darnley Islands in Torres Strait. Thursday Island has been a popular destination for butterfly collectors since the late 1800s-early 1900s (Mathew 1885,

Waterhouse and Lyell 1914) and more recently in the 1980s and 1990s, with *E. d. niveata* being frequently observed (Lambkin and Knight 1983, De Baar 1988, T.A. Lambkin unpublished data).



Fig. 1. Elgner's specimen of *Euploea darchia niveata* labelled 'Darnley Island, 13.iv.1910' [forewing length 38 mm]; photograph courtesy of the Australian Museum.

Of particular interest is the Darnley Island record of *E. d. niveata* by Waterhouse and Lyell (1914). This specimen (labelled 'Darnley Island, 13.iv.1910' and housed in the Australian Museum: Fig. 1), is one of many Torres Strait butterflies collected by Hermann Elgner, a German collector who made significant collections of Torres Strait butterflies and dragonflies predominately in the first decade of the 20th Century (Moulds 1977, Dunn 2007) (material housed in the Australian Museum and Museum Victoria). Darnley Island is volcanic in origin (Lambkin 2013) and located in the far eastern sector of Torres Strait. Since the rediscovery of the islands of Torres Strait as a focus for butterfly collecting in the late 1970s and 1980s (Monteith 1978), Darnley Island has been surveyed for butterflies by several collectors, commencing in the 1980s (e.g. Johnson 1983, De Baar 1988), through to the first decade of this century (T.A. Lambkin unpublished data). While several species of *Euploea* Fabricius have been collected over this period on Darnley Island, *E. d. niveata* remains the only *Euploea* taxon not to have been collected or observed there since Elgner's 1910 isolated 'collection'. Apart from this remote record, the butterfly is known in Torres Strait only from

Thursday Island in the very south of the region. *Trophis* (= *Malaisia*) *scandens* (Lour.) Hook. & Arn. (Moraceae), the recorded host plant of *E. d. niveata* (Manski 1939), has a patchy distribution in Torres Strait and is known to occur on Darnley Island (Lambkin and Knight 2005).

Hermann Elgner was based for some of his time in the Torres Strait region at Cape York (Moulds 1977) and undertook collecting forays to several Torres Strait islands (Moulds 1977, Dunn 2007). Of particular interest are his movements through several of the Torres Strait islands in 1910. What can be best determined, according to Moulds (1977) and Dunn (2007), is that Elgner's last reported collecting day on Thursday Island was 29 March 1910, followed by his (only recorded) visit to Hammond (Keriri) Island on 31 March and then to Moa (Banks) Island en route to Darnley Island. He arrived at Darnley Island on the 3 April for an extended period and returned to Cape York in either June or July that same year (Moulds 1977, Dunn 2007).

Dunn (2007) intensively reviewed the movements of H. Elgner, basing his study on roughly 1400 collected specimens. Dunn (2007) considered the accuracy of Elgner's labelling to be 'exemplary' at approximately 99%. While the overall veracity of Elgner's locality records cannot be disputed some errors have been detected (Meyer *et al.* 2004, Dunn 2007). The case of the *E. d. niveata* specimen discussed here seems to be possibly one of the rare Elgner errors in labelling. Although the possibility of a vagrant from the south-west (*i.e.* Cape York or Thursday Island) cannot be entirely discounted, the specimen is of fresh appearance and unlikely to have travelled such a long distance. It seems more likely that it was collected by Elgner on Thursday Island on or prior to 29 March 1910 and was not labelled until after he arrived at Darnley Island on 3 April 1910, thus being mistakenly labelled as originating from Darnley Island in April of that year.

The distribution of *E. d. niveata* appears to be almost entirely confined to mainland Queensland. How far west it extends along the coastal vine scrubs of the Gulf of Carpentaria, possibly into the Gove Peninsula of the Northern Territory, is currently unknown, as this region is rarely visited by lepidopterists. Despite a flurry of collecting, undertaken primarily during the 1980s and 1990s and then, to a lesser degree, since 2000 on several Torres Strait islands, including the southern group of islands that satellite Thursday [Waiben] Island (specifically Horn [Narupai], Hammond and Prince of Wales [Muralag]), Thursday Island remains the only location in Torres Strait where *E. d. niveata* has been observed or collected. However, it is likely that the butterfly might yet be found on those islands that satellite Thursday Island, since they support potential breeding habitat comprising patches of deciduous monsoon forest (T.A. Lambkin unpublished data).

Finally, taking into account the temporal movements of Hermann Elgner through Torres Strait in March and April 1910, and with the weight of

collecting data indicating that *E. d. niveata* appears to be endemic to tropical coastal Queensland and Thursday Island in the extreme south of Torres Strait, it seems unlikely that the butterfly's distribution encompasses Darnley Island as Elgner's label indicates.

Acknowledgements

Appreciation is given to J.S. Bartlett (Brisbane) for provision of the image of the H. Elgner specimen of *E. d. niveata* and providing access to material held in the Queensland Department of Agriculture, Fisheries and Forestry Collection, Brisbane. Thanks also to S. Ginn of the Australian Museum, Sydney for organising approval for publication of the image. M.F. Braby and A.G. Orr kindly provided their personal communications. This work partially fulfills the requirements for a Master of Philosophy degree undertaken by the author at the University of Queensland, Brisbane.

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PHENOLOGY OF THE AUSTRALIAN SOLITARY BEE SPECIES *LEIOPROCTUS PLUMOSUS* (SMITH) (HYMENOPTERA: COLLETIDAE)

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Abstract

A nesting aggregation of the bee species *Leioproctus (Leioproctus) plumosus* (Smith, 1853) in a suburban garden was observed for a period of seven years. Between one and three generations per year were observed and estimates obtained for the development time and lifespan of adults. The emerging bees were accompanied, at this site, by the parasitic ichneumonid wasp *Labium pettitorium* (Erichson, 1842).

Introduction

Surprisingly little is known about the life cycles of Australian bees in the family Colletidae, which contains 53% of named Australian species (AFD 2013). Several species in the family Apidae (Cardale 1968a, b, Steen and Schwarz 2000, Schwarz *et al.* 2007 and references therein, Halcroft *et al.* 2013) and one halictine species (Kukuk *et al.* 2005 and references therein), have received significant study but observations of colletids have been restricted to indirect inferences concerning the number of generations per year.

Observation of adult activity at times separated by more than 8 weeks has frequently been taken as an indication of two or more generations *per annum* (e.g. Houston 1971, 1975, 1987), based on the expectation that solitary bees have an active lifespan of only a few weeks (Michener 2007). Exceptions, like the queens of highly social species or species that overwinter as adults, are uncommon, although the colletid species *Amphylaeus morosus* is reported to live for up to a year (Spessa *et al.* 2000). The observations need to be made at the same or similar locations as the activity periods for univoltine species at different places may be widely out of phase (Houston 1991).

On this basis, six Australasian *Leioproctus* species are believed to be univoltine and six bivoltine or multivoltine (Rayment 1935, 1950, Donovan 1980, Houston 1990, Houston and Maynard 2012, Maynard 2013), but no detailed phenology of an Australian *Leioproctus* species has been reported.

Leioproctus plumosus (Smith) (Fig. 1) is widely distributed throughout Australia but predominantly in coastal regions in the southern half of the continent (Fig. 2). While Museum collection data (Fig. 3; ALA 2013) indicate that *L. plumosus* is active over an extended period, it is unclear whether this is an indication of multivoltinism or just the result of combining data from a range of environments.

A nesting aggregation of *L. plumosus* in a domestic garden in Ulladulla, a coastal site *ca* 170 km south of Sydney, NSW, provided an opportunity to examine the emergence of adult bees over a period of several years.

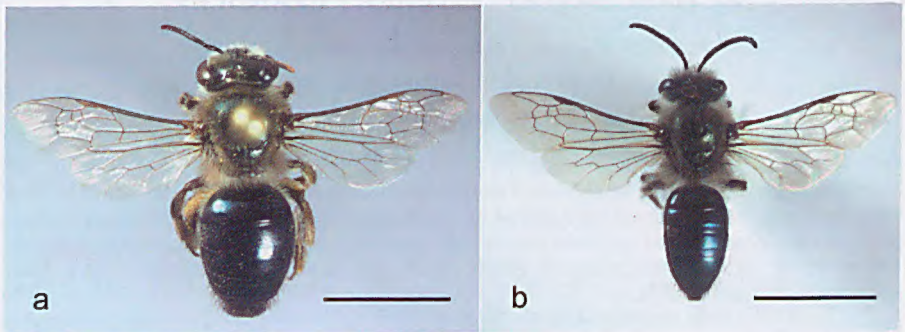


Fig. 1. *Leioproctus plumosus*: (a) female (b) male. Scale bars = 5 mm.

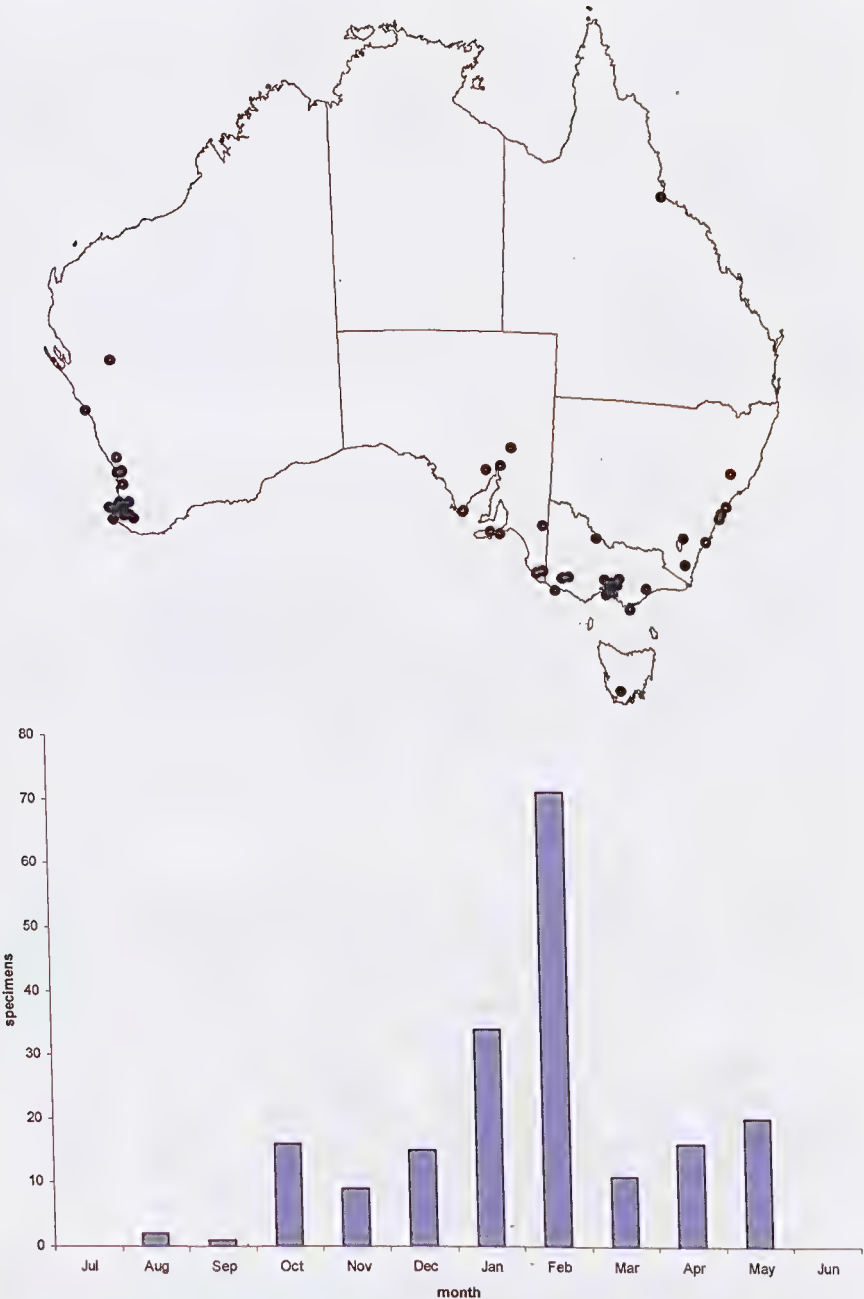
Methods

The activity of adult bees was monitored by visual observation of males flying near the ground and above vegetation in the vicinity of the nesting site and females returning to nesting tunnels in the ground. Observations were made over eight seasons from October 2005 to April 2013. No attempt was made to quantify the number of individuals. One male and three female bees, plus ten female ichneumonid wasps, were collected for identification. These specimens have been lodged in the Australian Museum.

Leioproctus plumosus specimens were identified using the male genitalia and hidden sterna (Maynard 2013). *Labium pettitorium* (Erichson, 1842) (redescribed by Turner and Waterston 1920) was identified by the coarse punctures on the scutum, the strong projections from the propodeum, overall colour and the number of flagellar segments. *Labium inflexum* (Morley, 1914), which was transferred to the genus *Labium* by Townes *et al.* 1961, is one of the few yellow *Labium* species and was identified by the colour pattern, including infuscation of the wing tips (Morley 1914). Records from the Australian Bureau of Meteorology automatic weather station number 69138 (Station name: Ulladulla AWS), were obtained from the Bureau's internet site (BOM 2013). The station is located 550 m from the nest site.

Results

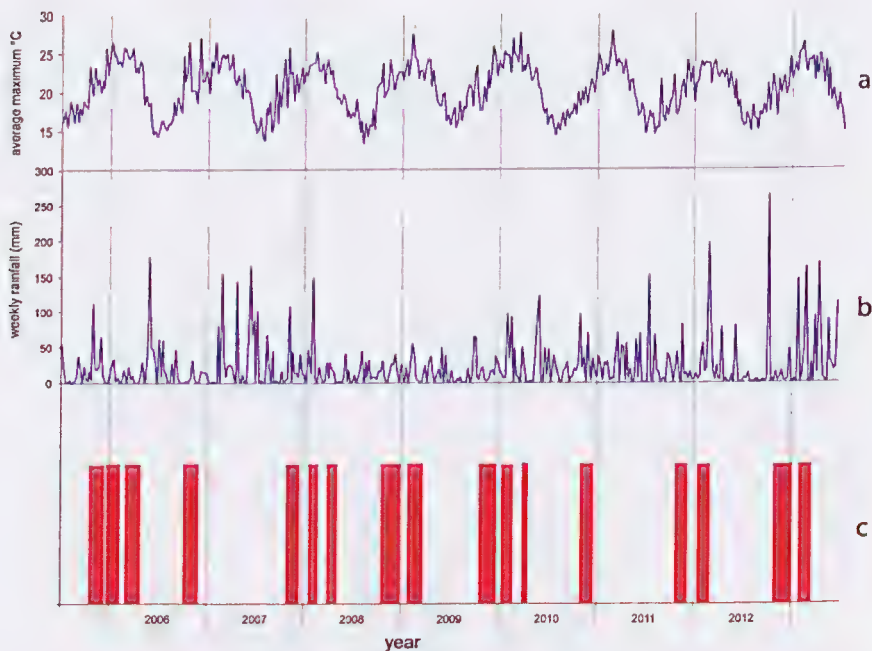
Each year the bees emerged in late October or early November and disappeared before the end of December (except in 2012). In six of the eight years, a second emergence was seen between the middle of January and the middle of February, although there was some variation in the exact starting date. In three of the years, a third emergence was seen in autumn (Table 1, Fig. 4), although on both occasions the number of bees seen was small.



Figs 2-3. (2) Location and (3) month collected for *Leioproctus plumosus* specimens recorded in Atlas of Living Australia.

Table 1. Emergence dates and length of active periods for *Leioproctus plumosus*.

year	emerged	active period (days)	emerged	active period (days)	emerged	active period (days)
2005-6	late Oct	?	1 Jan	37	8 Mar	37
2006-7	14 Oct	48				
2007-8	31 Oct	44	25 Jan	31	4 Apr	32
2008-9	30 Oct	60	3 Feb	49		
2009-10	26 Oct	61	19 Jan	33	2 Apr	17
2010-11	12 Nov	38				
2011-12	5 Nov	36	25 Jan	?		
2012-13	4 Nov	65	6 Feb	33		

**Fig. 4.** Weather parameters and nesting activity of *Leioproctus plumosus*: (a) weekly average maximum temperature; (b) weekly rainfall at Ulladulla AWS; (c) observed periods of activity at nesting site. Vertical scale indicates presence or absence of bees.

The mean length of the spring and summer activity periods was 45 days (s.d. 11 days), while the intervals between activity periods were estimated as differences between either the mid-points of activity or the dates of first emergence. The former gave an average of 75 days (s.d. 8 days), while first emergences were separated by an average of 83 days (s.d. 9 days).

Ichneumonid wasps, identified as *Labium pettitorium* (Erichson) (Fig. 5a), were frequently observed patrolling the nesting site. The wasps were first noticed in all years, but their number relative to that of the bees was noticeably high in 2010/11 and noticeably small in 2012/13. A different wasp species, *Labium inflexum* (Morley) (Fig. 5b), was found in another *L. plumosus* colony in a garden in the Sydney suburb of Lilyfield in October 2000, demonstrating that *L. plumosus* may be parasitised by more than one *Labium* species.

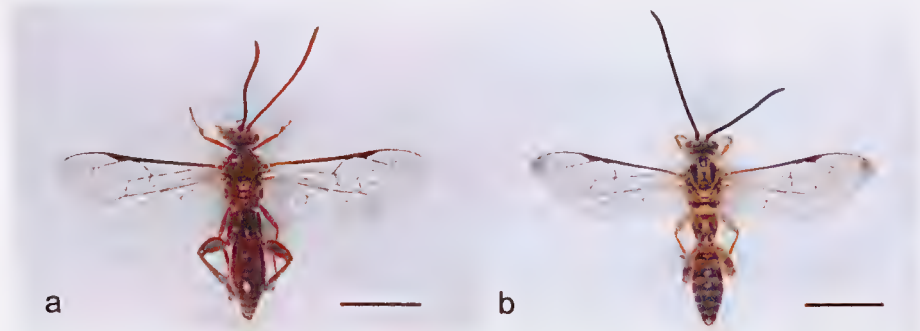


Fig. 5. *Labium* species: (a) *L. pettitorium* female; (b) *L. inflexum* female. Scale bars = 5 mm.

Discussion

The observations demonstrate that *Leioproctus plumosus* is unambiguously multivoltine and individuals have short lifetimes like many other solitary species (Michener 2007). Consequently, the extended period of activity shown in Fig. 3 can be explained by the blurring of gaps between generations by small variations in emergence times at different sites.

No attempt was made to estimate the lifespan of the bees by marking individuals, but the length of the active periods provides a rough estimate. Given that most female hymenopterans probably mate only once and consequently males emerge slightly earlier than females (Alcock *et al.* 1978), we estimate that individual bees of this species live for between 30 and 50 days.

Adults emerging in the second period of activity are probably offspring of bees that emerged in the first period rather than of bees active a year earlier. Consistent with this interpretation are the observations that (i) summer and autumn hatchings occurred even when there was only a spring hatching in the

previous year and (ii) no autumn emergence was seen in the absence of a summer generation in the same year (Fig. 4).

The time intervals between activity periods ranged from 65 to 90 days, which is comparable with the development times reported for other species. The minimum time for adult development of the ground-nesting species *Amegilla pulchra* was estimated to be 42-65 days (Cardale 1968a), similar to the 55 days found for *Austroplebeia australis* (Halcroft *et al.* 2013). Although *A. australis* is eusocial, its larvae develop within sealed cells. For other species, only the time between pupation and eclosion of the adults has been observed. For *Lithurgus atratiformis* the length of this pupal stadium was 22 days (Houston 1971), for *Amegilla paracalva* 22 days (Houston 1991) and for *Stenotritus greavesi* 51 days (Houston and Thorp 1984). Hence the intervals between periods of activity exhibited by *L. plumosus* are not shorter than those expected between generations.

The occasional failure of the summer and/or autumn generations does not seem to be correlated with either rainfall or maximum temperature (Fig. 4). In fact, the bees were particularly numerous in the spring of 2012 and summer of 2013 despite particularly heavy rain shortly before emergence. Three weeks before the spring emergence 233 mm of rain fell in 24 hours and one week before the summer emergence there was a fall of 105 mm.

No obvious correlation was observed between bee emergence and flowers in bloom at the time. *Leioproctus plumosus* is known to visit a range of flowers from at least four plant families (Maynard 2013) and the area within a radius of 400 m around the nesting site consisted entirely of suburban gardens in which exotic species were predominant. Furthermore, the bees are active over a period longer than the flowering time of most plants and must therefore exploit several flower species. Hence it is unlikely that the emergence times have become synchronised with the blooming of any particular flower.

A more likely explanation for the variations is that the number of bees is affected by parasitism, as has been suggested for other species (Dolphin 1979). Although the number of *L. pettitorium* wasps was not measured, their number was noticeably high in 2010/11, when the summer and autumn generations failed to appear and noticeably low in 2012/13, when bee numbers were greater than average.

Conclusion

Relatively little is known about the life history of Australian bees, yet simple observations of a nesting site over an extended period of time could provide useful information not available from accumulated museum records. Collections usually contain a small number of specimens from each site and the data are, therefore, averaged over a range of sites and times, leading to a blurring of information. Citizen scientists could make valuable contributions (Danielson *et al.* 2003) to the understanding of our bee fauna.

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MODIFICATION OF THE ALL PROTOCOL TO CHARACTERISE THE OVERALL ANT ASSEMBLAGE IN TEMPERATE EUCALYPT FOREST

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Abstract

A standardised sampling procedure for ants, the ALL (Ants of the Leaf Litter) Protocol, was modified for use in temperate eucalypt forest. Terrestrial samples from leaf litter and pitfalls (the basic ALL Protocol) were supplemented with arboreal samples from tree traps. Four 200 m transects were sampled using the modified protocol within a 0.5 ha site on a forested property located near the mid-north coast of New South Wales. Site vegetation was mixed-age eucalypt forest, which had been undisturbed for more than 30 years. Tree traps captured a total of 54 species and 19 of these were absent from terrestrial samples. The addition of tree traps to the basic ALL Protocol: i) increased the number of species detected per species occurrence by an average of 20% per transect, with almost 2/3 of the increase due to species of *Camponotus*, *Polyrhachis* and *Myrmecia*; ii) increased the proportion of common species collected in transects, with less variation in species numbers between transects; and iii) provided a more comprehensive characterisation of this ant assemblage. Three groups of ants were present in the assemblage: 1) widespread species, active both in litter and on trees; 2) small litter-dwelling terrestrial species; and 3) larger species which were captured primarily on trees but were mostly ground-nesting. The genera of ants detected at the site were largely shared with similar east coast sites. Voucher specimens were deposited at the Australian Museum and images of the ants are available by email from the author.

Introduction

Australian ants have been extensively used as bioindicators to monitor environmental changes (Majer *et al.* 2004) and also as a target group in biodiversity surveys (Stanisic *et al.* 2005, Burwell and Nakamura 2011, Callan *et al.* 2011). However, thorough assessments of ant biodiversity are time-consuming and often involve specialist entomologists (Andersen *et al.* 2002). In an effort to make invertebrate assessments easier to conduct, rapid survey procedures have been developed using simplified methods for sampling, sorting and identification of specimens (Oliver and Beattie 1996). Andersen *et al.* (2002) simplified the assessment procedure by sorting only larger ant species from 12 selected genera and thereby reduced the survey effort while achieving similar conclusions to those of a more intensive survey. A rapid sampling procedure, the Ants of the Leaf Litter (ALL) Protocol, has been proposed for assessing ant assemblages of the forest floor from samples collected by pitfall trapping and extraction of ants from leaf litter using mini-Winkler sacks. This standardised sampling methodology enables direct comparisons between sites and between studies (Agosti and Alonso 2000). The ALL Protocol was developed for tropical forests, where distinct assemblages of arboreal and litter ants occur, but there is little evidence for this distinction in temperate forests (Gotelli *et al.* 2011). In Australian eucalypt forests few ant species are known to nest and forage primarily in trees, but ground-nesting species may forage in trees (Andersen

and Yen 1992) and some of these species appear to do so preferentially when leaf litter is well developed on the ground (Andersen 1995). Ants which forage largely in trees and strictly arboreal species are both likely to be under-represented in terrestrial samples collected with the basic ALL Protocol. Several ant surveys with a focus on the overall ant assemblage in tropical habitats have included tree traps to sample the arboreal stratum (Andersen *et al.* 2006, Andersen *et al.* 2007).

The present study examined the use of baited tree traps to supplement ground samples collected with the basic ALL Protocol in a temperate eucalypt forest and thereby provide a less biased description of the overall ant assemblage. A relatively undisturbed site with a well developed leaf litter layer was surveyed using multiple transects and the modified ALL Protocol. Results from individual transects were inspected for changes in species richness and species composition due to the addition of tree-trap samples.

Methods

Study site

The study site was located on a 400 ha property on the eastern fall of the Great Dividing Range, near the NSW mid-north coast (31.513°S, 152.246°E, 500 m altitude, mean annual rainfall 1150 mm). The property was almost entirely forested and surrounded by similarly forested lands. The topography consisted of ridges with moderate slopes. Disturbances over the past century included cattle grazing, timber harvesting and frequent fires. Prior sampling had indicated the presence of a relatively rich ant fauna on a sheltered slope with north-west aspect which had been free from these disturbances for more than 30 years and this was selected for the study area. The study site was located mid-slope and limited to 0.5 ha to avoid changes in soil moisture and ground vegetation on the upper slope and lower slope.

Site vegetation consisted of dry eucalypt forest, with an open mixed-age canopy dominated by Grey Gum (*Eucalyptus propinqua*), Grey Box (*E. moluccana*) and Forest Red Gum (*E. tereticornis*). The open understorey was mostly Black Oak (*Allocasuarina littoralis*) and the shrub layer was sparse. The closed ground cover consisted of grasses (*Themeda*, *Entolasia*), Matrush (*Lomandra*), sedges (*Gahnia*) and a well-developed leaf litter layer of 2-5 cm depth. The soil was finely textured, compact and stony, with patches of surface stones, gravel, logs, branches and debris.

Sampling

Four linear 200 m transects (A-D) were sampled with the modified ALL Protocol at the study site during January and February, 2011. Successive transects were displaced at least 10 m to avoid overlap. Sampling stations were located at 10 m intervals along each transect. Terrestrial samples from litter and a pitfall, together with an arboreal sample from a tree trap, were collected at each station (a total of 20 samples per method per transect).

Each leaf litter sample was collected from an area of 1 m², sieved to remove coarse material and placed in 5 mm mesh plastic containers which were suspended in mini-Winkler sacks for 48 hours (Bestelmeyer *et al.* 2000) at temperatures of 17-38°C. Emergent ants were collected in 80% methylated spirits. Pitfalls and tree traps were constructed from plastic cups, 65 mm diameter and 90 mm depth, partly filled with 80% methylated spirits as collecting fluid and operated for 48 hours. Pitfalls were dug into the ground and shaded with plastic containers. Tree traps were pinned to a tree trunk at 1.5 m height and baited around the rim with honey (Fig. 1). Observations of ant nests were recorded as: 1) in the ground or in wood on the ground; or 2) above ground in dead wood of standing trees.



Fig. 1. Tree trap attached to the trunk of a canopy eucalypt by upholstery pins, partially filled with 80% methylated spirits and baited around the rim with honey.

Ants were identified to genus using keys by Shattuck (1999) and CSIRO (2012), then separated into morphospecies (referred to as species hereafter) and identified to described species or species-group where suitable keys were available. Voucher specimens were deposited at the Australian Museum and images of all morphospecies detected are available by email from the author.

Data analysis

Performance of the modified ALL Protocol was qualitatively assessed from the increase in the number of species collected and the change in species composition in each transect relative to data from the terrestrial samples of the basic ALL Protocol.

At each sampling station within transects, data from litter and pitfall samples were pooled for the basic ALL Protocol and this was pooled with the data from the tree traps for the modified ALL Protocol (*i.e.* 20 pooled-method samples per transect). Incidence data were used as it has been advocated as a more appropriate unit of ant biodiversity than the abundance of individual ants (Ellison *et al.* 2007, Gotelli *et al.* 2011). Incidence (occurrence) was recorded as the presence or absence of a species in each sample of pooled-methods data or in each sample collected by individual methods.

The numbers of species and species occurrences were recorded and the software EstimateS 8.2 (Colwell 2009) was used to compute species accumulation curves for transect data. Species detected were plotted against species occurrences rather than samples, to reduce bias due to differences in ant numbers (Gotelli *et al.* 2011). The number of species collected in each transect was compared at a value of species occurrences corresponding to the least total for any transect. At this value, the number of species in each transect was estimated, where necessary, by interpolation between points in the species accumulation data.

Changes in species composition were identified by inspection of the incidence data collected by the basic and modified ALL Protocols for each transect.

Results

Species richness

The numbers of species occurrences, genera and species collected were greatest in litter samples and least in pitfalls (Table 1). Transects varied in the numbers of species occurrences and species detected, with greater variation between transects collected with the basic ALL Protocol than with the modified ALL Protocol (Fig. 2).

Data from tree traps supplemented basic ALL Protocol data by an average of 84 species occurrences, three genera and 14 species per transect (Table 1). The number of species collected in each transect ranged from 47 to 60 for the basic ALL Protocol and 61 to 70 for the modified ALL Protocol (Fig. 2), representing differences between transects of up to 28% and 15% respectively.

The modified ALL Protocol accumulated more species per species occurrence than the basic ALL Protocol. Transect B with basic ALL Protocol yielded 309 species occurrences, the least number for any transect and the

data for the remaining transects were standardised to this value. At 309 species occurrences, transects with the basic ALL Protocol averaged 51 species and this increased by 20% to 61 species with the addition of data from the tree traps used in the modified ALL Protocol (Table 1).

Table 1. Species occurrences at the site. Totals for each sampling method are the combined data for four transects. Average values per transect (based on the four transects) compare the basic (Bas.) and modified (Mod.) ALL Protocol using: a) raw data; and b) data standardised to 309 species occurrences.

	Species occurrences	Genera	Species
Totals			
Litter	1216	39	79
Pitfalls	265	24	39
Tree traps	485	25	54
Average/transect			
a) raw data			
Bas. ALL Protocol	331	31	52
Mod. ALL Protocol	415	34	66
b) standardised to 309 sp. occ.			
Bas. ALL Protocol	309		51
Mod. ALL Protocol	309		61

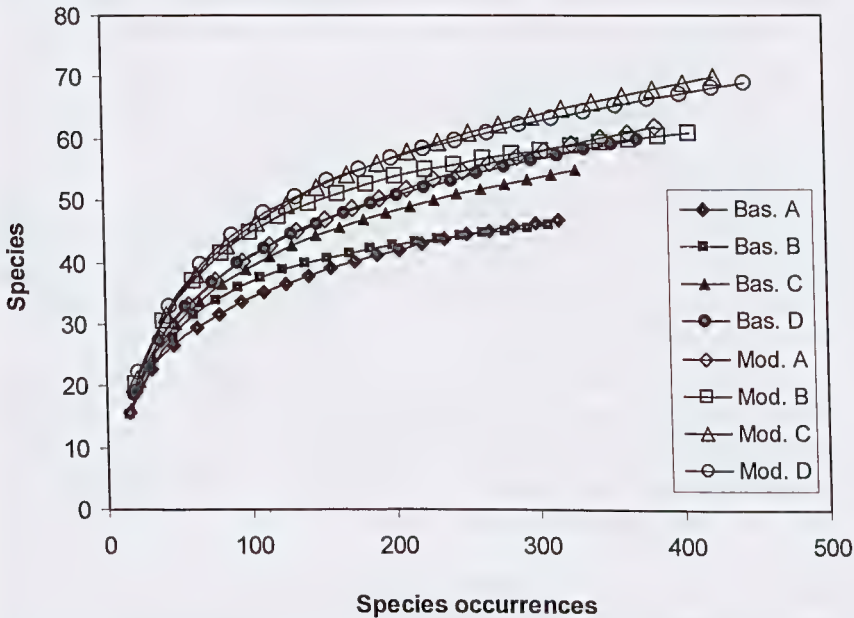


Fig. 2. Species accumulation curves (based on species occurrences) for each of the four transects (A-D) using data from the basic ALL Protocol (Bas.) and modified ALL Protocol (Mod.).

Composition of the ant assemblage

Ant species detected at the site are listed in Table 2. The species composition of the assemblage in terrestrial samples (litter and pitfalls) differed from that in arboreal samples (tree traps). A total of 54 species was collected in tree traps (Table 1). Terrestrial samples collected 46 species not captured by tree traps; another 35 species were present in both strata and 19 species were captured only in tree traps (Table 2). Ten subfamilies of ants were present in terrestrial samples, while tree traps contained ants from only five subfamilies (Table 2). Differences in species composition between ants collected with the basic and modified ALL Protocols were most conspicuous in the three subfamilies Formicinae, Myrmicinae and Myrmeciinae. The modification to the ALL Protocol added totals of 11, four and three species, respectively, to these subfamilies (Table 2). Twelve of the 19 species unique to tree traps were from the genera *Camponotus*, *Polyrhachis* and *Myrmecia* (Table 2). The modification to the ALL Protocol added an average of 8.5 species per transect from these three genera, representing 61% of the overall increase in species numbers.

The subfamilies Myrmicinae and Formicinae accounted for 68% of species collected from transects and 71% of species occurrences. The Myrmicinae were comprised largely of small species active in leaf litter, with few of these species active on tree trunks. The Formicinae consisted of a mixture of small species which were primarily active in the ground litter and large mobile species which were active on tree trunks but rarely captured on the ground.

Genera which were common in samples from one stratum, but not the other, included *Pheidole*, *Stigmacros*, *Hypoponera*, *Solenopsis* and *Lordomyrma* in terrestrial samples and *Camponotus*, *Polyrhachis*, *Myrmecia* and *Leptomyrmex* on tree trunks. Genera that were common both on the ground and on tree trunks were *Anonychomyrma*, *Nylanderia*, *Meranoplus* and *Crematogaster*. The genus *Rhytidoponera* included two similar species with differing habitat preferences: *Rhytidoponera victoriae* (André) was common only on the ground, while *Rhytidoponera metallica* (Smith) was common both on the ground and on tree trunks.

Forty-four of the collected species were considered common as they occurred at more than 10% of sampling stations (*i.e.* incidence greater than 8 in the Mod column in Table 2). Of these 44 common species, at least 42 (95%) were collected along each of the four transects with the modified ALL Protocol, while each transect with the basic ALL Protocol collected at least 36 (82%).

Ant nests were observed on or near the site for 23 of the 54 species active on tree trunks and nests of 18 of these species were in the ground or in wood lying on the ground, while those of five species were arboreal in dead standing trees of *Eucalyptus*, *Acacia* and *Allocasuarina* (Table 2).

Table 2. Total number of species occurrences (incidence) in 80 samples each from: **L**, litter; **P**, pitfalls; **T**, tree traps; **Bas**, basic ALL Protocol; and **Mod**, modified ALL Protocol. Nest sites (**N**) for species active on trees are denoted as: **G**, in the ground or in wood on the ground; or **A**, above ground in standing dead wood.

Species	L	P	T	Bas	Mod	N
Amblyoponinae						
<i>Amblyopone</i> sp. 1	3	0	0	3	3	
<i>Prionopelta robynmae</i> Shattuck	1	0	0	1	1	
<i>Stigmatomma</i> sp. 1	1	0	0	1	1	
Cerapachyinae						
<i>Cerapachys turneri</i> Forel	5	0	0	5	5	
<i>Cerapachys larvatus</i> (Wheeler)	4	0	0	4	4	
<i>Sphinctomyrmex</i> sp. 1	1	0	0	1	1	
Dolichoderinae						
<i>Anonychomyrma</i> sp. 1	50	33	33	61	72	G
<i>Anonychomyrma</i> sp. 2	6	2	1	6	6	
<i>Iridomyrmex splendens</i> Forel	7	5	18	10	21	G
<i>Iridomyrmex mayri</i> Forel	3	4	6	6	12	G
<i>Leptomyrmex nigriventris</i> (Guérin)	0	2	18	2	19	A
<i>Ochetellus</i> sp.1 (<i>glaber</i> group)	1	0	0	1	1	
<i>Ochetellus</i> sp.2 (<i>glaber</i> group)	1	0	3	1	4	G
<i>Tapinoma</i> sp.1	35	0	2	35	36	
<i>Tapinoma</i> sp.2	0	0	1	0	1	
Ectatomminae						
<i>Rhytidoponera metallica</i> (Smith)	14	13	25	25	39	
<i>Rhytidoponera victoriae</i> (André)	56	36	3	63	63	G
Formicinae						
<i>Acropyga myops</i> Forel	1	0	0	1	1	
<i>Camponotus aeneopilosus</i> Mayr	3	2	24	4	28	G
<i>Camponotus elegans</i> Forel	1	0	46	1	46	G
<i>Camponotus</i> sp.6 (<i>intrepidus</i> group)	0	0	26	0	26	G
<i>Camponotus</i> sp.7 (? <i>humilior</i>)	0	0	21	0	21	G
<i>Camponotus</i> sp. 9 (near <i>elegans</i>)	0	0	3	0	3	
<i>Camponotus</i> sp.12 (<i>sponsorum</i> group)	0	0	1	0	1	
<i>Camponotus macrocephalus</i> Erichson	0	0	1	0	1	
<i>Melophorus</i> sp. 1	1	0	0	1	1	
<i>Melophorus</i> sp. 2	2	0	1	2	3	G
<i>Notoncus capitatus</i> Forel	25	15	17	33	37	
<i>Nylanderia</i> sp. 1	0	0	5	0	5	A
<i>Nylanderia</i> sp. 3	58	3	59	59	71	
<i>Paraparatrechina</i> sp. 2 (<i>minutula</i> group)	38	3	4	38	40	G
<i>Paraparatrechina</i> sp. 4 (<i>minutula</i> group)	26	1	2	27	27	

Species	L	P	T	Bas	Mod	N
<i>Polyrhachis</i> sp. 2	0	0	1	0	1	G
<i>Polyrhachis phryne</i> Forel	2	0	26	2	27	
<i>Polyrhachis sidnica</i> Mayr	0	0	5	0	5	
<i>Polyrhachis</i> sp. 11	1	0	3	1	4	A
<i>Polyrhachis</i> sp. 15	0	0	1	0	1	
<i>Polyrhachis</i> sp. 16	0	0	3	0	3	
<i>Prolasius</i> sp. 1	14	1	5	15	19	
<i>Prolasius</i> sp. 2	51	5	2	54	54	
<i>Prolasius</i> sp. 3	44	6	7	44	46	
<i>Prolasius</i> sp. 4	2	1	0	3	3	
<i>Prolasius</i> sp. 5	2	0	0	2	2	
<i>Pseudonotoncus hirsutus</i> Clark	0	0	1	0	1	
<i>Stigmacros</i> sp. 1	19	0	0	19	19	
<i>Stigmacros</i> sp. 2	12	0	7	12	17	G
<i>Stigmacros</i> sp. 4	24	0	0	24	24	
<i>Stigmacros</i> sp. 5	38	1	0	38	38	
<i>Stigmacros</i> sp. 6	1	0	1	1	2	
<i>Stigmacros</i> sp. 8	18	1	0	18	18	
Heteroponerinae						
<i>Heteroponera</i> sp. 1 (<i>imbellis</i> group)	29	5	0	33	33	
Myrmeciinae						
<i>Myrmecia nigrocincta</i> Smith	1	1	12	2	14	G
<i>Myrmecia brevinoda</i> Forel	0	0	3	0	3	G
<i>Myrmecia</i> sp.3 (<i>gulosa</i> group)	0	0	1	0	1	
<i>Myrmecia fulvipes</i> Roger	1	0	0	1	1	
<i>Myrmecia</i> sp.9 (<i>mandibularis</i> group)	0	0	1	0	1	
Myrmicinae						
<i>Carebara</i> sp. 1	22	1	0	23	23	
<i>Colobostruma alinodis</i> Forel	1	1	0	2	2	
<i>Colobostruma lacuna</i> Shattuck	1	0	0	1	1	
<i>Crematogaster</i> sp. 1	20	2	33	21	43	A
<i>Crematogaster</i> sp. 2	14	12	2	22	24	
<i>Crematogaster</i> sp. 6	3	0	3	3	6	
<i>Epopostruma wardi</i> Shattuck	0	0	1	0	1	
<i>Lordomyrma</i> sp.1	47	0	0	47	47	
<i>Mayriella spinosior</i> Wheeler	5	3	0	8	8	
<i>Mayriella</i> sp. 2 (near <i>abstinens</i>)	2	0	4	2	6	
<i>Mayriella abstinens</i> Forel	1	0	0	1	1	
<i>Meranoplus</i> sp. 1	43	26	17	49	54	G
<i>Mesostruma browni</i> Taylor	10	0	0	10	10	
<i>Monomorium rubriceps</i> Mayr	0	0	1	0	1	G

Species	L	P	T	Bas	Mod	N
<i>Monomorium tambourinensis</i> Forel	40	1	0	40	40	
<i>Monomorium sydneyense</i> Forel	3	0	4	3	7	
<i>Monomorium fieldi</i> Forel	7	5	4	11	14	A
<i>Monomorium</i> sp. 7 (? <i>sydneyense</i>)	1	1	0	2	2	
<i>Monomorium leae</i> Forel	1	0	0	1	1	
<i>Orectognathus phyllobates</i> Brown	1	0	0	1	1	
<i>Orectognathus antennatus</i> Smith	0	0	1	0	1	G
<i>Orectognathus rostratus</i> Lowery	7	0	0	7	7	
<i>Orectognathus</i> sp. 5 (? <i>clarki</i>)	2	0	5	2	7	
<i>Pheidole</i> sp. 1	55	35	4	65	66	
<i>Pheidole</i> sp. 2	63	14	0	66	66	
<i>Pheidole</i> sp. 4	1	0	0	1	1	
<i>Pheidole</i> sp. 6	2	0	0	2	2	
<i>Pheidole</i> sp. 7	0	1	2	1	3	
<i>Podomyrma</i> sp. 2	0	0	1	0	1	
<i>Solenopsis</i> sp. 1	53	12	0	55	55	
<i>Solenopsis</i> sp. 2	2	2	0	4	4	
<i>Solenopsis</i> sp. 3	22	1	0	23	23	
<i>Strumigenys perplexa</i> Smith	33	0	0	33	33	
<i>Strumigenys</i> sp. 2	11	0	0	11	11	
<i>Tetramorium confusum</i> Bolton	6	1	4	7	11	
Ponerinae						
<i>Hypoponera</i> sp. 1	76	5	0	77	77	
<i>Hypoponera</i> sp. 2	3	0	0	3	3	
<i>Hypoponera</i> sp. 3	1	0	0	1	1	
<i>Leptogenys</i> sp. 1	2	1	0	3	3	
<i>Pachycondyla</i> sp. 1	12	1	0	13	13	
<i>Pachycondyla</i> sp. 2	1	0	0	1	1	
<i>Ponera leae</i> Forel	5	0	0	5	5	
Proceratiinae						
<i>Discothyrea</i> sp. 1	34	0	0	34	34	
<i>Discothyrea</i> sp. 2	1	0	0	1	1	

Discussion

Evaluation of the modified ALL Protocol

In this study the ant assemblage in a temperate eucalypt forest was sampled with the terrestrial sampling methods of the basic ALL Protocol supplemented by arboreal samples collected with baited pitfall traps on tree trunks. The modification to the ALL Protocol yielded a modest increase in the number of species detected, a clearly identifiable change to the species

composition of the ants collected in each transect, and less variable estimates of species richness and species composition.

The addition of tree traps increased the number of species collected in each transect and some of this increase can be attributed to the extra species occurrences generated by the tree traps. However, when the data were standardised to species occurrences the modified ALL Protocol collected an average of 20% more species per transect, indicating that it accumulated species more efficiently than the standard ALL Protocol despite the increase in sampling effort. The additional field time required for the modified ALL Protocol was minimal as the tree traps were installed and operated concurrently with the ground pitfalls.

The composition of the ant assemblage collected with the standard ALL Protocol was partly altered by the addition of tree traps. Substantial changes were confined to the subfamilies Formicinae and Myrmeciinae, in which the number of species collected increased by 50% and 250% respectively. The additional species were mostly from *Camponotus*, *Polyrhachis* and *Myrmecia*, genera which were infrequently present in the unbaited pitfall and litter samples collected with the standard ALL Protocol. These results appear to support the observations of Andersen (1995) that subordinate Camponotini, such as *Camponotus* and *Polyrhachis*, avoid well developed litter by foraging in trees. However, these ants may have been present and active on the ground, but not readily collected by unbaited pitfalls in the well developed litter cover at the site. Ants are more likely to be captured in pitfalls when the surrounding ground cover has a relatively open structure (Melbourne 1999). Dense litter cover reduces pitfall capture rates (Bestelmeyer *et al.* 2000) and Andrew *et al.* (2000) found that *Camponotus* was more common on the ground at burnt rather than unburnt forest sites. The use of bait may also influence the capture rate for pitfalls as Romero and Jaffe (1989) captured more ant species in savanna habitats when pitfalls were baited with meat, although Wang *et al.* (2001) reported that unbaited pitfalls were more effective in temperate oak forest. Greenslade and Greenslade (1971) collected more *Camponotus* ants when pitfalls were baited with syrup. Thus, the probability of detecting any *Camponotus* species that is active on the ground may improve if honey bait is added to the ground pitfalls used in the basic ALL Protocol. Other baits, such as meat or fish, have potential to collect additional species as Kaspari and Yanoviak (2001) found that canopy ants in a tropical forest preferred meat baits to sugar baits.

Although individual transects collected with the modified ALL Protocol did not detect all species collected at the site they captured a greater proportion of the common species than transects with the basic ALL Protocol. The number of species per transect differed less between transects collected with the modified ALL Protocol than between those collected with the basic ALL

Protocol. Together, these results indicated that the modified ALL Protocol provided less variable estimates of species richness and species composition than the basic ALL Protocol.

For studies which aim to maximise the species inventory of an overall ant assemblage, the improved sampling efficiency of the modified ALL Protocol should outweigh the slight increase in field time required to implement the tree traps.

The ant assemblage

Features of the ant assemblage at the study site were the large number of species active on tree trunks and the proportion of these which were under-represented in terrestrial samples. Previous studies indicated limited and patchy arboreal ant activity in southern Australian eucalypt forests (Majer 1990), although 37 species were recorded as active in eucalypt canopies in New South Wales (Majer *et al.* 2000) and 44 species were detected in the canopy of mallee eucalypts in northwestern Victoria (Andersen and Yen 1992). In the present study, 54 species were present in tree trap samples and a third of these were absent from the ground samples collected with the basic ALL Protocol.

The overall assemblage was comprised of three groups of species: 1) those widespread and common in both strata; 2) those primarily in terrestrial samples; and 3) those primarily in arboreal samples. Species in the widespread group included ants in a range of sizes from the subfamilies Dolichoderinae, Formicinae, Ectatomminae and Myrmicinae and they were from functional groups described by Andersen (1995) as comprising species which are usually abundant and unspecialised. The terrestrial group was the most diverse and consisted mainly of small cryptic species of Formicinae, Myrmicinae and Ponerinae, which are typical of habitats with well developed leaf litter (Andersen 1986, 1995, Hoffmann and Andersen 2003). The arboreal group was characterised by larger species of Formicinae and Myrmeciinae, which have been reported to be predominantly ground nesting (Andersen and Yen 1992). Within this group only five of the 23 nests observed during the present study were located above ground. Although ground nests of *Camponotus* were found up to 10 m distant from canopy trees, these ants were uncommon or rare in ground samples but more commonly collected on tree trunks. The arboreal group represented a substantial proportion of the species present and the combination of terrestrial and arboreal samples provided a more comprehensive inventory of the ant assemblage at this eucalypt forest site.

The genera found at the site were similar to those found elsewhere in eastern Australian eucalypt forests, with the majority also occurring 40 km to the east at Bulls Ground State Forest (York 2000, Andrew *et al.* 2000) and at forest

sites near Brisbane (Stanisic *et al.* 2005). However, shared genera can mask differences in species composition and to facilitate comparisons of species composition, Callan *et al.* (2011) retained reference specimens and provided online images of all ant species detected in their study at Barrow Island.

Ecological studies typically employ small plots and generate data which may not be immediately applicable at larger scales (Andersen 1997). However, the use of standardised sampling, as in the modified ALL Protocol, enables baseline data to accumulate from successive studies and provides the potential for comparative analysis at both local and regional scales. The results of this study support the use of multiple sampling methods for biodiversity assessment in order to offset the bias of individual methods and to improve detection rates for species which utilise more than one habitat.

Acknowledgements

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TWO NEW SPECIES OF *ABANTIADES* HERRICH-SCHÄFFER (LEPIDOPTERA: HEPIALIDAE) FROM WESTERN AUSTRALIA

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Abstract

Abantiades lineacurva sp. n. and *Abantiades argentangulum* sp. n. are described, illustrated and compared with other Australian species of Hepialidae.

Introduction

The genus *Abantiades* Herrich-Schäffer is endemic to southern Australia, with the northernmost occurrence listed by Tindale (1932) as Rockhampton, Queensland. The genus was last revised by Tindale (1932), who included 14 species, six described as new. Tindale's revision formed the basis of the works by Nielsen (1996), Nielsen *et al.* (2000), Edwards (2007) and Kallies and Douglas (2008). Since 1932, nothing of significance has been published on this genus and no new species have been described.

The genesis of this paper was a reorganisation of the South Australian Museum hepialid collection, which contains approximately 500 specimens of *Abantiades*, including all the described species. Curation revealed specimens of two unnamed species from Western Australia. Subsequent examination of the hepialid collection in the Australian National Insect Collection revealed two more unnamed Western Australian species.

In this paper we describe two new species from these collections.

Terminology used for the genitalia follows Dugdale (1994); that of the wing venation follows Kristensen (1998).

Abbreviations: ANIC – Australian National Insect Collection, Canberra; CSIRO – Commonwealth Scientific and Industrial Research Organisation; BMNH – The Natural History Museum, London, UK; SAMA – South Australian Museum, Adelaide; WAM – Western Australian Museum, Perth.

Systematics

Tindale (1932) described *Abantiades* thus: 'Antennae unipectinate often broad and lamellate in males, reduced in females. Labial palpi three-segmented, first and second segments approximately equal, apical one short, about as long as wide and subspherical, maxillary pair reduced, forming ill-articulated protuberances at base of labium. Forewings R1 separating from Rs before the branching of R5; R4 and R5 forked. Hindwings with R4 and R5 branching before the radio-median cross-vein.' The type species is *A. hyalinatus* Herrich-Schäffer, 1853, designated by Kirby in 1892.

Abantiades lineacurva sp. n.

(Figs 1-7).

Types. *Holotype* ♂, WESTERN AUSTRALIA: Kojonup, 18.iv.1960, Wallace, in ANIC. *Paratypes*: 21 ♂♂, 6 ♀♀, WESTERN AUSTRALIA: 1 ♂, 1 ♀, Kellerberrin, 14.v.1939, Tindale; 1 ♂, Kojonup, 6.iv.1960, Beresford, in SAMA; 1 ♂, Kojonup, 11.iv.1961, Priest; 1 ♂, Kojonup, 11.iv.1962, Peters; 1 ♂, 1 ♀, Nedlands, 22.iv.1964, 21.iv.1964, Wallace; 15 ♂♂, 2 ♀♀, Kojonup, 10.iv.1963, 13.iv.1963, 17.iv.1963, 21.iv.1963, 22.iv.1963, 23.iv.1963, 14.iv.1964, 16.iv.1964, 17.iv.1964, 19.iv.1964, 21.iv.1964, 4.v.1964, 12.iv.1965, 19.iv.1966, 8.v.1967, Rogers; 1 ♀, Bakers Hill, 9.v.1968, I. Southey, in ANIC; 1 ♂, Jacup, 1.v.1914, W.B. Alexander, 33°46'S 119°17'E, in WAM.

Additional material examined. WESTERN AUSTRALIA: 1 ♀, Katanning, 1879; 1 ♂, Hale, 8.vii.1872, Bailey; 2 ♂♂, Jacup, v. 1914; 1 ♂, Jacup, v.1919; 1 ♂, Carlingup, v. 1919, in WAM.

Diagnosis. Male and female: antennae paler at tip with broad flattened rami; forewing dark brown with a prominent 'T' shaped silver-white marking which does not reach apex, without intricate scroll-like pattern; hind wing dark brown, only slightly paler towards base.

Description. Male (Fig. 1). Head: proboscis absent; labial palpi three segmented, apical one short sub-spherical, narrow, directed forwards; antennae red brown, paler towards tip, short, about a third length of costa, unipectinate, rami in middle about 2.0-2.5 x shaft, sub-elliptical in shape, covered in very short fine cilia (Fig. 7), leading edge flattened; frons and vertex with dark brown hair scales. Thorax: densely covered in dark brown hairs, legs dark brown. Abdomen: densely covered in dark brown hairs.

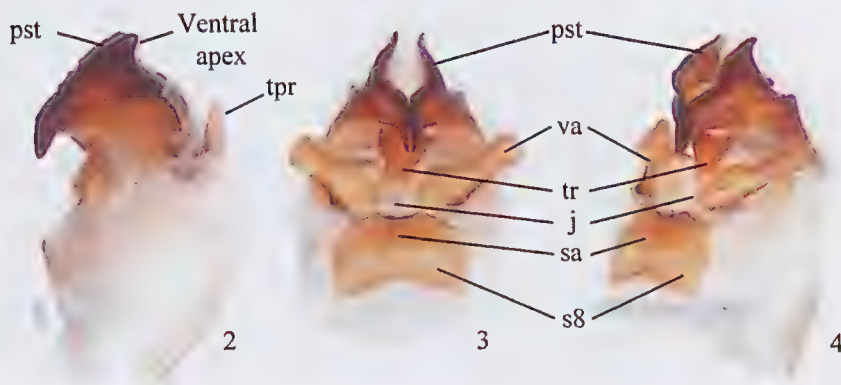
Forewing: length 30-34 mm, costa straight, gently rounded towards tip, termen and dorsum evenly and continuously rounded; upperside dark brown with silver markings and without intricate scroll-like pattern, a fine silver subterminal disjointed line from Rs2 to below CuA1, a parallel silver disjointed line subapically from Rs1 to postmedially below CuA1, from the middle of this line there extends a long longitudinal angularly undulating line to the costal vein near base, a short disjointed silver line, sometimes obsolete, runs from Rs1 inwards and not reaching Rs3, cilia dark brown. Hindwing: costa slightly arched, apex rounded, termen and dorsum evenly rounded, dark brown, slightly paler basally, cilia dark brown; underside of both wings dark brown with muted silver pattern showing through forewing.

Genitalia. (Figs 2-4). Pseudotegumen heavily sclerotised, wedge shaped, ventral apex projected rearwards in a strong curve, tip obtuse, anterior vertex 'beak-like', anterior margin somewhat serrate, posterior margin less. Each side of pseudotegumen curves outwards then narrows as it rises towards apex, lateral edge curves outwards at apex producing a mild horned effect in most specimens. Twin processes short, set well back. Valva short, paddle

shaped, dorsal edges more heavily sclerotised. Trulleum sclerotised, roughly trapezoid in shape with anterior apices lobed. Juxta; weakly bilobed, weakly sclerotised. Saccus broadly 'V' shaped, posterior edge heavily sclerotised with two acute points at its midline. Sternite 8; posterior margin with sizeable concave notch.



Fig. 1. Adult male of *Abantiades lineacurva* sp. n.: upperside



Figs 2-4. Male genitalia of *Abantiades lineacurva* sp. n.: (2) lateral, (3) ventral, (4) ventrolateral. j = juxta; pst = pseudotegumen; s8 = sternite 8; sa = saccus; tpr = twin processes; tr = trulleum; va = valva.



Fig. 5. Adult female of *Abantiades lineacurva* sp. n.: upperside

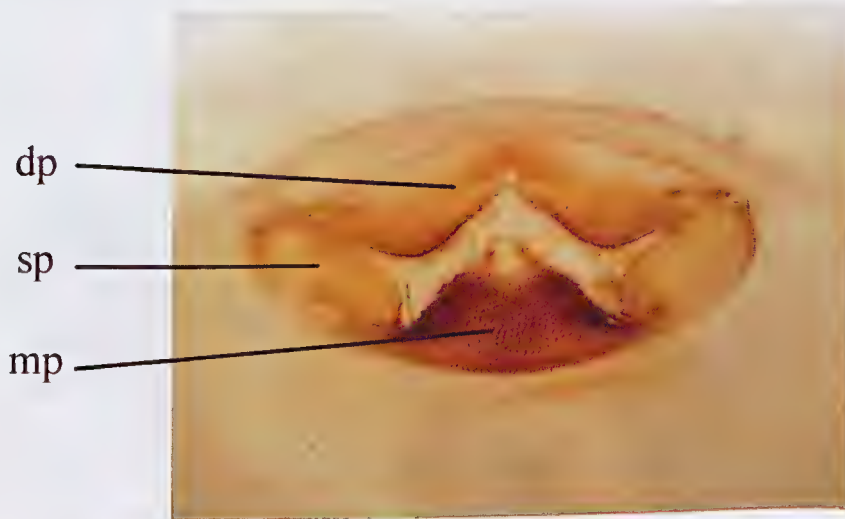


Fig. 6. Female genitalia of *Abantiades lineacurva* sp. n.: ventral view. dp = dorsal plate; mp = median piece; sp = side piece. Ductus bursae and corpus bursae not shown.

Female (Fig. 5). Head: proboscis and palpi as male; antennae as male but shorter, about one-sixth length of costa, unipectinate, rami mid antenna about $1.5 \times$ shaft, strongly flattened and subelliptical, covered in very fine short cilia (Fig. 7). Thorax as in male. Abdomen densely covered in dark brown hairs. Forewing: length 50-70 mm, colour and pattern similar to male but more elongate. Hindwing similar to male but more elongate.

Genitalia (Fig. 6). Anogenital field wider than high. Dorsal plate lobes triangular, setose, lightly sclerotised. Median piece distinctly bi-cuminate, setose, heavily sclerotised. Side pieces sub-elliptical.

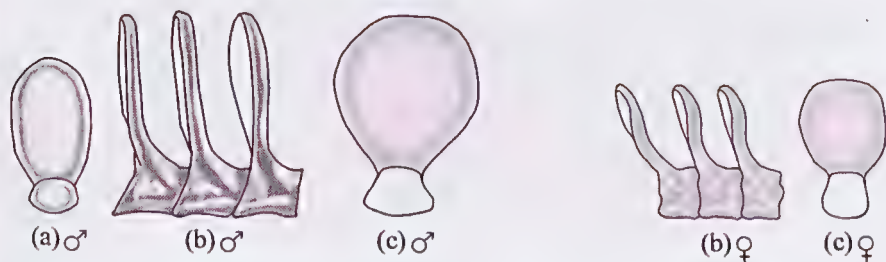


Fig. 7. Antennal segments of male (left) and female (right) of *Abantiades lineacurva* sp. n.: (a) terminal ramus, (b) mid rami-lateral view, (c) mid ramus.

Variation. The extent and detail of the silver markings on the forewings vary as in other species of *Abantiades*.

Etymology. *lineacurva* (Latin) – curved line referring to the longitudinal, angularly undulating silver line that is the most conspicuous forewing mark.

Distribution. Most specimens were collected at the CSIRO light trap at Kojonup. It is also known from the Perth area, Bakers Hill in the eastern Darling Range, Kellerberrin in the wheat belt east of Perth, and Jacup and Carlingup in the southern mallee (Fig. 8).

Comments. *Abantiades lineacurva* is the only Western Australian species that has grey-brown fore and hind wings and a prominent, single white line on the forewing. *Abantiades albofasciatus* Swinhoe, 1892 also has a single major white stripe on its forewing but it is wider, angled rather than curved, and reaches the apex. *Abantiades albofasciatus* also has intricate scroll-like markings on the upperside of the forewing and a hind wing that is white. *Abantiades aurilegulus* Tindale, 1932 is golden-brown rather than dark brown in colour and has two prominent lines on its forewing.

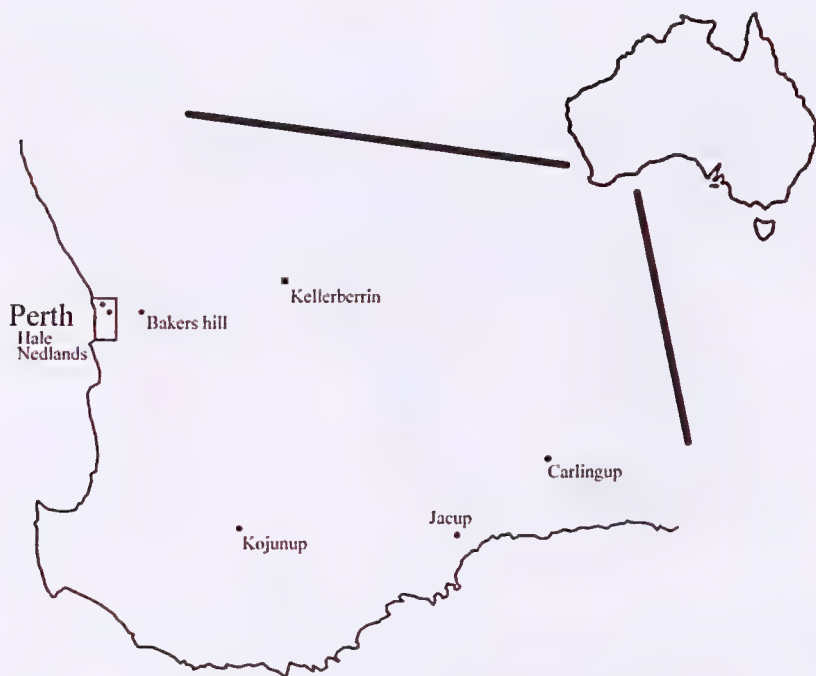


Fig. 8. Capture sites of *Abantiades lineacurva* sp. n.

Abantiades argentangulum sp. n.

(Figs 9-16)

Types. *Holotype* ♂, WESTERN AUSTRALIA: Yanchep National Park, 5 miles north of Yanchep, 12.iv.1968, I. Common and M. Upton, in ANIC. *Paratypes*: 7 ♂♂, 2 ♀♀, WESTERN AUSTRALIA: 1 ♂, Kojonup, 8 iv 1964 A. L. Rogers, in SAMA; 2 ♂♂, 1 ♀, Konjunup? 2-11.iv.1962, A.L. Peters; 3 ♂♂, 21 miles west of Kojonup, 28.iii.1968, I. Common and M. Upton; 1 ♂, Pithara, 25.iv.1968; 1 ♂, Peak Charles NP, 16.iv.2007, A. Zwick and C. Cocking; 1 ♀, Coolgardie Goldfield Woodlands NP, 17.iv.2007, A. Zwick and C. Cocking, in ANIC; 1 ♂, 1 ♀, Dryandra State Forest, 12.8 km SE of Caballing, 5.iv.1984, R.P. McMillan, in WAM.

Additional material examined. WESTERN AUSTRALIA: 4 ♂♂, Lake Magenta Reserve, 17 m E. Pingrup, 4.iv.1971, D. Kitchener and L. Smith; 1 ♂, Lake Magenta Reserve, iv.1971, L. Smith; 2 ♂♂, Dryandra State Forest, 12.8 km S.E. of Caballing, 5.iv.1984, R.P. McMillan; 1 ♂, 20 m N.E. of Corrigan, 15.iv.1963, A.C. Morton; 1 ♂, Gooseberry Hill, v.1970, E. Mullins; 1 ♂, Valema Farms, Corrigan, iii.2001-2002 Insect Survey, M. Golding and I. Pitman; 1 ♂, Gosnells, 21.iv.1939, W. Stevens; 1 ♂, Fitzgerald River National Park, 9-11.iv.1982, T. Houston; 1 ♂, Dryandra State Forest, iv.1972, A. Burbridge; 1 ♂, Glen Forest, 16.iv.1974, I. Lyon; 1 ♂, Carlingup, 3.vii.1914, W.B. Alexander; 1 ♂, West Perth, 1.iv.1937, A. Holder; 1 ♂, Shackleton,

31.v.1922, L. Morrison; 1 ♂, no data, M. Powell Collection; 1 ♀, Cheritons Find, 11.iv.1971, B. Evans, all in WAM.

Diagnosis. Male: antennae with broad flattened spade shaped rami; forewing dark grey-brown with two prominent, silver-white, triangle shaped markings; hind wing mid brown, more yellowish towards base. Female: antennal rami absent; forewing grey with scroll pattern.



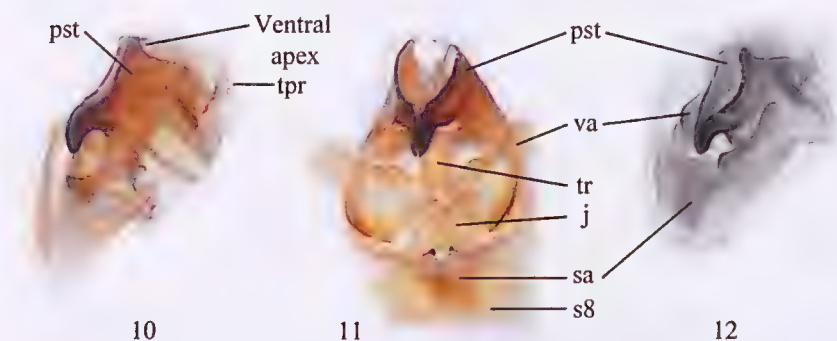
Fig. 9. Adult male of *Abantiades argentangulum* sp. n.: upperside.

Description. Male (Fig. 9). Head: proboscis absent; labial palpi three segmented, apical segment short, subspherical, directed anteriorly; antennae, 65-73 segments, dark chestnut-brown, short, about a third length of costa, unipectinate, rami mid filament 3 x shaft, strongly flattened, at base sub-elliptical, mid antenna spade shaped, at termen near triangular, densely covered in short fine cilia (Fig. 16); frons, covered in long grey hairs. Thorax, covered in long brown hairs; legs, covered in stiff hairs; forelegs, femur inner yellow, outer black, edge white; tibia, brown and yellow; tarsi, grey tipped white; mid legs, all grey tipped white; hind legs yellow. Abdomen covered in long dark, grey-brown hairs.

Forewing: length 52-60 mm, costa straight gently rounded towards tip, tip acute, termen and dorsum continuously gently curved giving wing a narrow lanceolate shape, upperside, pale brown, darker at base; two large silver-white markings, one thin and lanceolate from near tip to below CuA1 approximately parallel to termen, second triangular with vertices at the origin of M3, join CuA1 with M3 and 0.4 distance along Rs4, both edged dark

brown, between, a sparse line of small circles edged mid brown; slight scrolling near dorsum, fine mid brown lines fill other spaces; close to termen a thin off white line runs between Rs4 and A1; underneath, light brown tending darker at the costa, coating of yellowish hairs to the basal part. Hindwing: costa straight, curving towards tip, tip obtuse, termen and dorsum evenly rounded; upperside light brown grading to yellowish buff at base; underside light brown, yellowish hairs at base.

Genitalia (Figs 10-12). Pseudotegumen; heavily sclerotised, ventral apex acute, triangular, with slight posterior projection, tip obtuse, anterior apex heavily hooked, anterior margin somewhat concave, posterior sinuously curved, thickened, bumpy. Twin process; short, strongly pointed. Valva; 'arms' short, broad at base, rugose, curved and sclerotised along ventral surface. Trulleum; large, lightly sclerotised, angled posteriorly, anterior apices lobed. Juxta; weakly sclerotised, large, posterior roundly bilobed, anterior lateral acute lobes. Saccus; broadly 'V' shaped, curved anterior apex, posterior with two sclerotised points along midline. Sternite 8; posterior margin gentle convex curve.



Figs 10-12. Male genitalia of *Abantiades argentangulum* sp. n.: (10) lateral, (11) ventral, (12) ventro-lateral. j = juxta; pst = pseudotegumen; s8 = sternite 8; sa = saccus; tpr = twin processes; tr = trulleum; va = valva.

Female (Fig. 13). Head: proboscis and palpi as male, antennae dark chestnut-brown, short, one fifth costa, non pectinate, rami reduced to bumps that abut, producing an ongoing series of undulations along the length of the filament, well covered with short white setae over the entire surface, some longer setae on underside of filament (Fig. 16). Thorax covered in long brown hairs; legs mid to dark brown. Abdomen as male. Forewing: 77-90 mm, similar to male except the silver-white markings are replaced with subdued, non-contrasted, pale grey-brown areas, the spaces between filled with scroll-like markings. Hindwing: upperside similar to male but paler; underside light brown.



Fig. 13. Adult female of *Abantiades argentangulum* sp. n.: upperside.

Genitalia (Figs 14-15). Anogenital field wider than high. Dorsal plate; deeply cleft, lobes distinct, pear-shaped, setose, lightly sclerotised. Median plate, shape distinctly mound-like, setose, heavily sclerotised. Side plates roughly triangular. Intergenital lobe wide trapezoidal. The bursae copulatrix occupies the entire length of the female abdomen. Ductus bursae and corpus bursae of about equal length, diverticulum at intersection.

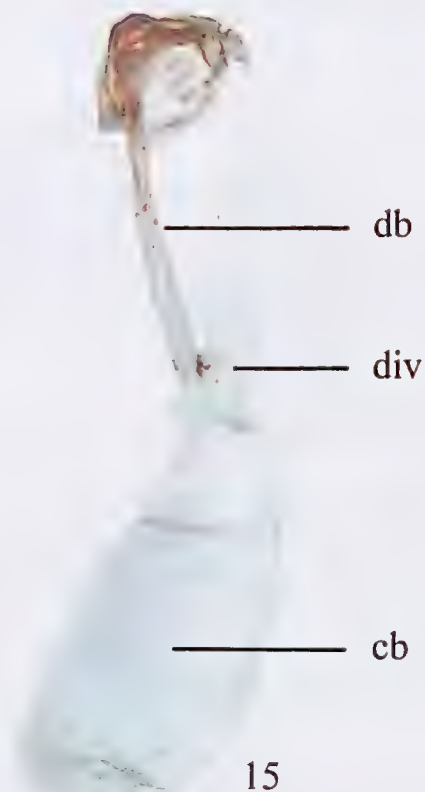
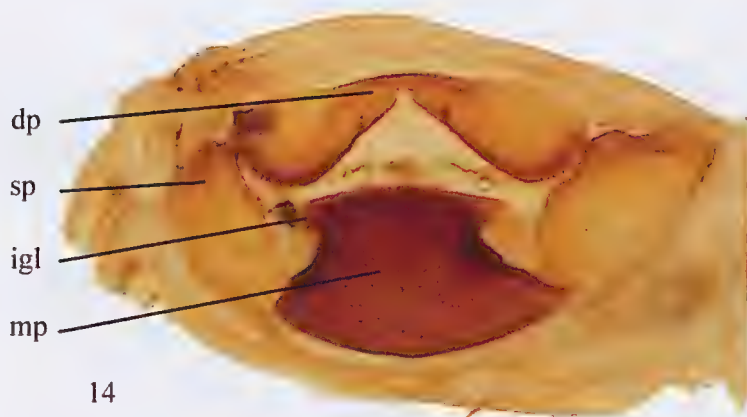
Etymology. *argentangulum* (Latin) – referring to the angular silver marking prominent on the forewing of the male.

Distribution. Widely distributed over the southwestern part of WA (Fig. 17).

Comments. *Abantiades argentangulum* is easily separated from all other Western Australian *Abantiades* species: males by the striking silver-white triangles on the forewings, females with rami absent from antennae. This species has been collected extensively in the past and has for many years been referred to as the ‘WA magnificus’. It has only now been studied in sufficient depth to establish its specific status.

Biology

We know nothing significant of the biology of either species, although rainfall data for the capture sites and times of the above mentioned specimens indicate that emergence of this species is linked to autumn and winter frontal rainfall events, similar to that known for other hepialid species.



Figs 14-15. Female genitalia of *A. argentangulum* sp. n.: (14) anogenital area; Ventral view, (15) bursae copulatrix. dp = dorsal plate; igl = intergenital lobe; sp = side piece; mp = median piece; db = ductus bursae; cb = corpus bursae; div = diverticulum.

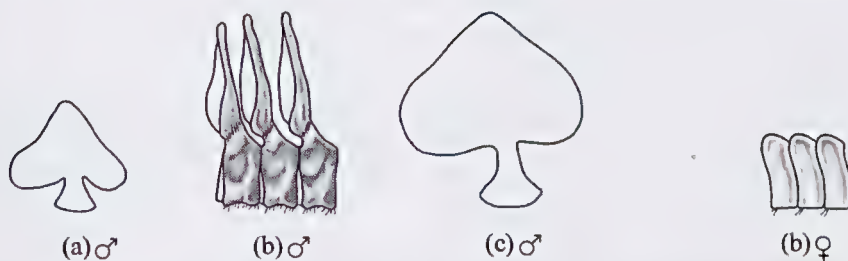


Fig. 16. Antennal segments of male (left) and female (right) of *Abantiades argentangulum* sp. n.: (a) terminal ramus, (b) mid rami-lateral view, (c) mid ramus.



Fig. 17. Capture sites of *Abantiades argentangulum* sp. n.

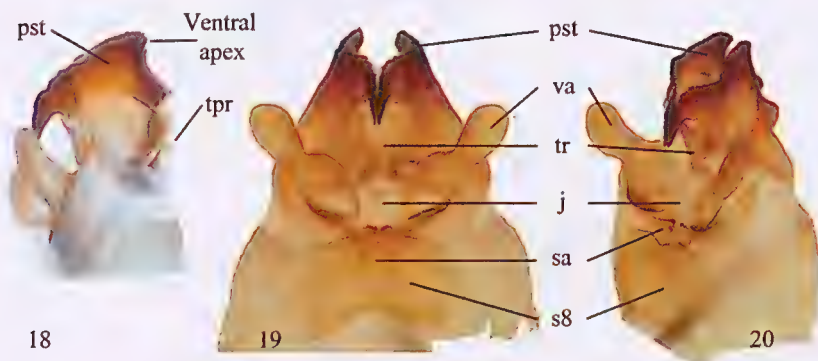
Discussion

Abantiades lineacurva is similar to another Western Australian species, *Bordaia moesta* Tindale, 1932 in size, shape, colour and markings but differs in its appearance, antenna and genitalia. When describing *Bordaia* Tindale (based on the type species *B. pica* Tindale), Tindale (1932) noted that it has an appearance like *Oxycamus* Walker but venation like *Abantiades*, where R4

and R5 on both wings were stalked, whereas in *Oxycanus* R5 arises from the stem of R₂₊₃₊₄. Unlike *Abantiades*, which has unipectinate antennae, *Bordaia* has bipectinate antennae.

Bordaia moesta was known for many years only from the holotype in SAMA but recently a further male has been discovered in the WAM collection. Both specimens have yellow bipectinate antennae, whereas *A. lineacurva* has deep reddish brown, unipectinate antennae.

Although the overall structure and form of the genitalia of *A. lineacurva* and *B. moesta* are similar, there are differences in the structures of various parts (Figs 2-4 and 18-20). In *A. lineacurva* the genitalia are more heavily sclerotised, the valva are broader and thicker, the trulleum smooth in outline with diverging anterior projections, the posterior margin of the juxta is distinctly linear, the ventral projection of the pseudotegumen is curved, acutely angular and backward pointing, and the twin processes much longer. The notch in S8 also differs. The anterior projections on the trulleum of *B. moesta* have an interesting spear-pointed shape.



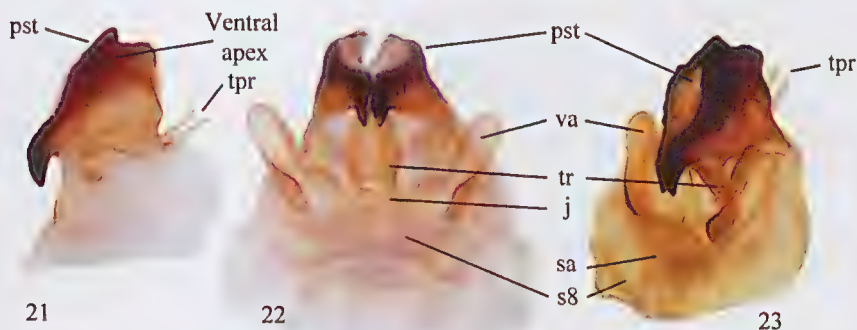
Figs 18-20. Male genitalia of *Bordaia moesta*: (18) lateral, (19) ventral, (20) ventro-lateral: j = juxta; pst = pseudotegumen; s8 = sternite 8; sa = saccus; tpr = twin processes; tr = trulleum; va = valva.

The close structural similarity of the male genitalia of *Abantiades* and *Bordaia* do, however, hint at a closer similarity than the antennal differences would indicate. A careful study of the generic limits of *Bordaia* and *Abantiades* is needed to clarify the position of these genera and this is being undertaken by Thomas Simonsen (BMNH) (pers. comm).

Abantiades argentangulum most resembles the eastern Australian *A. magnificus* (Lucas, 1898). The similarities in the two species indicate a close relationship. Males of both species have large, silver-white triangles on their forewings but in *A. argentangulum* the silver-white markings are relatively larger with a smaller area of dark brown scales surrounding them. Hind wings

on *A. argentangulum* are yellowish and distinctly lighter than the forewing, whereas in *A. magnificus* the hind wings are grey-brown and darker than the forewings. Antennae: in *A. argentangulum* the rami are larger, 3.0 x the filament width and, although not bilateral, are distinctly spade shaped, whereas in *A. magnificus* the plates are smaller, 1.5 x the filament width and orbicular to lanceolate in shape. Females of the two species can only be separated using genital structures.

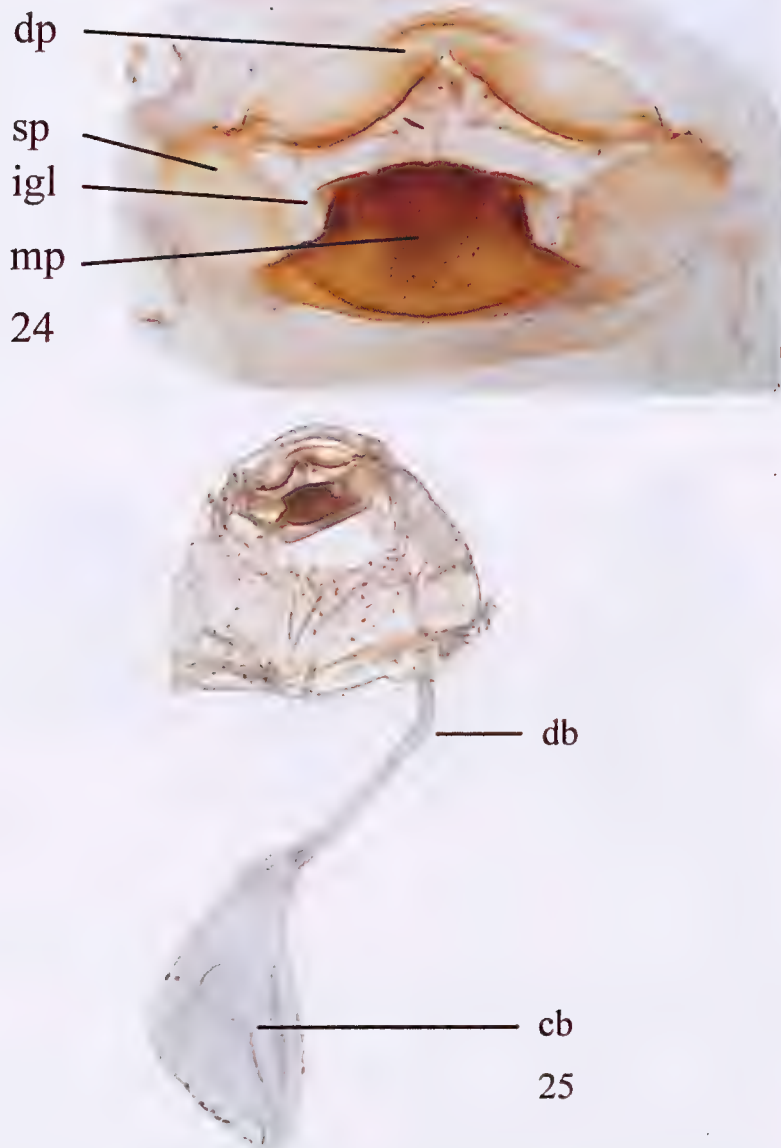
Comparison of the genitalia shows specific differences. In males (Figs 10-12 and 21-23), the slope of the posterior margin of the pseudotegumen in *A. argentangulum* is curved but distinctly stepped and steeper in decline in *A. magnificus*; the trulleum in *A. argentangulum* is longer with anterior projections present but pentagonal shaped and lacking projections in *A. magnificus*; the juxta in *A. argentangulum* has apical projections, is proportionally larger and has the posterior margin lobed but in *A. magnificus* is without apices, is proportionally smaller and lacking lobes on the posterior margin; valves with 'arms' relatively shorter in *A. argentangulum*.



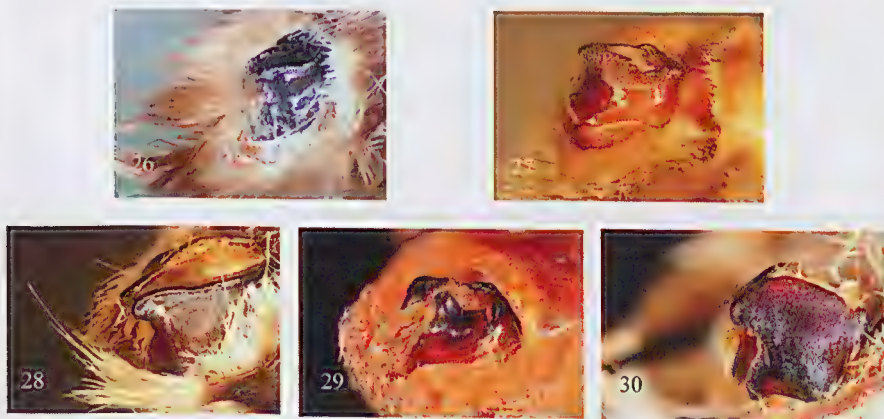
Figs 21-23. Male genitalia of *Abantiades magnificus* (21) lateral, (22) ventral, (23) ventro-lateral: j = juxta; pst = pseudotegumen; sa = saccus; tpr = twin processes; tr = trulleum; va = valva.

In females (Figs 14-15 and 24-25), differences can be found in the morphology of the dorsal plate (lobes in *A. magnificus* are more evenly rounded than in *A. argentangulum*) and of the bursae copulatrix (*A. argentangulum* has a diverticulum, *A. magnificus* does not).

Abantiades argentangulum is widespread in southwestern Australia, living in a wide variety of open woodland types. *Abantiades magnificus* is from eastern Australia, ranging from the New England area of NSW along the great divide to Moe and the Grampians. Neither species has been recorded in South Australia. On the basis of distinct morphological differences in overall appearance (in males), antennal shape (in males), genitalia structures, their geographical separation and their differences in habitat preference, we believe that *A. argentangulum* and *A. magnificus* are separate species.



Figs 24-25. Female genitalia of *Abantiades magnificus*. (24) anogenital area, (25) bursae copulatrix. dp = dorsal plate; sp = side plate; mp = medial plate; igl = intergenital lobe; db = ductus bursae; cb = corpus bursae.



Figs 26-30. Ventrolateral views of pseudotegumen; (26) *Abantiades lineacurva*, (27) *Bordaia moesta*, (28) *A. argentangulum*, (29) *A. aurilegulus*, (30) *A. hydrographus*.

Remarks

When working with older specimens of Australian hepialids, care is required when describing colour differences. The appearance of specimens when first caught may be brighter and more colourful, with some colours fading or disappearing as the specimen ages. Irrespective of the age of the specimen, differences outlined above hold true.

In the genus *Abantiades* there seems to be two forewing shapes exhibited by the various species: longer, more lanceolate forewings such as in *Abantiades argentangulum* and a broader forewing as exhibited by *A. lineacurva*.

Identifying *Abantiades* species without dissection

Sometimes it is convenient not to dissect the male genitalia, in which case parts of the pseudotegumen may be seen by brushing away some scales around the genital area (Figs 26-30). Tindale (1935) used this technique in studying *Oxycanus*. It has the disadvantage that important characters may be hidden; the degree of extrusion of the male genitalia in different specimens will differ and so will be more or less visible.

Acknowledgements

We thank Peter Hudson for suggesting the project, his ongoing support, patience and forbearance in all things and for critically reading the manuscript, Chris Watts for his support, detailed reading and critical analysis of our writing, You Ning Su for his instruction on the use of the mounting camera and help and support with the imaging and computer graphics and Howard Hamon for his construction of the final images and distribution maps, Thanks must also be given to the staff of SAMA, WAM and ANIC for access to specimens and their equipment.

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AN ANNOTATED KEY TO THE *RIOXA* COMPLEX OF GENERA (DIPTERA: TEPHRITIDAE: ACANTHONEVRINI)

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Abstract

The *Rioxa* complex of Indo-Australian fruit flies is reviewed and keyed. The 14 recognised species are referred to 6 genera: *Cribroriox*a Hering (1 sp.), *Ectopomyia* Hardy (2 spp), *Hexacinia* Hendel (3 spp), *Hexamela* Zia (1 sp.), *Rioxa* Walker (6 spp) and *Sophiroides* Hendel (1 sp.). *Hexacinia punctifera* (Walker, 1861), *H. multipunctata* Malloch, 1939 and *H. flavipunctata* Hering, 1940 are placed as new synonyms of *H. stellipennis* (Walker, 1860), while *Rioxa quinque*maculata Bezzi, 1913 and *R. vittata* Zia, 1963 are placed as new synonyms of *R. parvipunctata* de Meijere, 1911, **stat. rev.** and *R. sexmaculata* (van der Wulp, 1880) is placed as a new synonym of *R. discalis* (Walker, 1861). *Acinia marginemaculata* Macquart, 1851 is excluded from *Hexacinia*. A record of *Hexacinia stellipennis* from Sumatra is regarded as an error, while those of *Rioxa lanceolata* Walker from Sri Lanka and China are regarded as misidentifications of *R. parvipunctata*. Known larval hosts are fallen logs.

Introduction

This is the third in a series of papers reviewing and keying Indo-Australian and East Asian fruit flies referred to the *Acanthonevra* group in tribe Acanthonevrini (*sensu* Korneyev 1999) of subfamily Phytalmiinae. It deals with the *Rioxa* complex, which occurs from Sri Lanka and India eastwards to the Philippines and Papua New Guinea. Previous papers dealt respectively with the *Acanthonevra* and *Sophira* complexes (Hancock 2011, 2012).

Korneyev (1999) placed *Rioxa* Walker, *Ectopomyia* Hardy and *Hexacinia* Hendel in an apparently monophyletic clade within his *Acanthonevra* subgroup in the *Acanthonevra* group of genera. *Hexamela* Zia was regarded as a close ally of *Hexacinia* by Zia (1963) and Wang (1998). *Cribroriox*a Hering was included in this complex by Hancock (2005) and *Sophiroides* Hendel also appears to belong here (Hancock 2012).

All available biological information is recorded under the [incorrect] name '*Rioxa sexmaculata*'. Hardy (1986) collected specimens of [*R. parvipunctata* de Meijere] 'in mating flight around buttress of a large forest tree in botanical garden' in Bogor, Java and suspected that they might breed in rotting wood. This was confirmed by Kovac *et al.* (2010), who recorded oviposition in holes made by bark beetles or other insects in recently fallen trees in northern Thailand. Permkam (1995) collected individual specimens of [*R. discalis* (Walker)] (Fig. 1) attracted to cut shoots of the bamboos *Thyrostachys oliveri* and *Bambusa arundinacea* on three separate occasions in southern Thailand, suggesting that a casual relationship with bamboo also exists.

An annotated key to the 6 genera and 14 species recognised in this study is provided below, with several other taxa previously included in *Hexacinia* or *Rioxa* here synonymised or excluded (see Discussion). Illustrations of most species may be found in Hardy (1973, 1974, 1986) and Wang (1998).

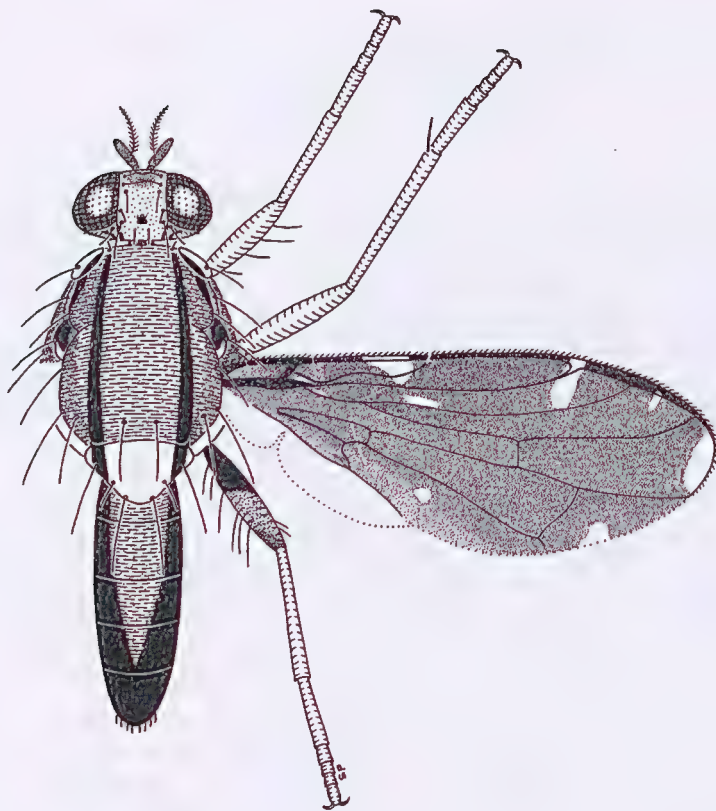


Fig. 1. *Rioxa discalis* (Walker): male from West Malaysia.

Key to genera and species

* = New distribution records based on material in The Natural History Museum, London (BMNH).

- 1 Wing pattern largely brown, yellowish basally almost to apex of cell c and with a faint brown transverse band medially, with a transverse posterior yellow indentation from wing margin across cells cu_1 and dm into cell br and with a narrow yellow transverse band from cell r_1 near apex of stigma into cell dm between R-M and DM-Cu crossveins that is broadly produced as a 2-pronged marking into subapical parts of cells r_{2+3} and r_{4+5} ; a shallow hyaline indentation in cell m along wing margin; scutum yellow with 4 dark longitudinal vittae, the dorsocentral pair not extending onto scutellum; face concave in profile; presutural setae absent; secondary scutellar setae weak and hair-like [Sri Lanka; *Rioxa magnifica* Senior-White, 1921 is a synonym; illustrated by Hardy 1968]
 *Sophiroides flammosus* Hendel, 1914

- Not as above; wing pattern blackish brown with hyaline or subhyaline spots and indentations 2
- 2 Scutum pale medially with a pair of dark dorsocentral vittae extending over sides of scutellum; pleura normally with dark vittae but not distinctly spotted; wing with vein Sc distinctly arcuate and cell m with a narrow marginal band or single small hyaline indentation; head with upper frontal setae often not close to lower setae and not reclinate; anepisternum without an additional dark seta near ventral margin centrally 3
- Scutum largely yellow with or without dark spots or dark medially with pale submedial vittae extending most of its length; pleura yellow or with brown to black spots; wing with vein Sc not distinctly arcuate and cell m with 1 large or 2 small hyaline indentations; head with upper frontal setae very close to lower setae and reclinate; anepisternum with or without an additional dark seta near ventral margin centrally 9
- 3 Wing with numerous subhyaline discal spots but no distinct hyaline marginal indentations, at most small hyaline spots towards apex of cell r_1 and over apices of veins R_{2+3} and R_{4+5} and a narrow marginal band in cells m and cu_1 ; cell c apically blunt; head setae mostly yellow [eastern Indonesia (Sumba)] *Cribrorioxia perforata* Hering, 1952
- Wing without numerous discal spots but with distinct hyaline indentations in cells r_{2+3} , r_{4+5} and m, that in cell r_{4+5} oval and almost filling apex; cell c apically acute; almost all head setae brown to black [*Ptilonina* Enderlein, 1911 is a synonym] *Rioxia* Walker, 1856 ... 4
- 4 Wing veins R_1 and R_{2+3} approximate at apex, with vein R_{2+3} less than 1/4 distance between veins R_1 and R_{4+5} ; cell r_{4+5} with a large hyaline basal spot that is more than half width of cell; cell dm often with a small subapical hyaline spot; either cell br with a broad hyaline streak or cell cu_1 with an isolated anteromedial spot 5
- Wing vein R_{2+3} more than 1/3rd distance between veins R_1 and R_{4+5} ; cell dm entirely dark, cell br with at most a faint narrow streak and cell r_{4+5} normally with at most a tiny basal spot (large in most *megispilota*) 6
- 5 Wing cell br with a broad and elongate hyaline streak extending almost to R-M crossvein [Malaysia (West, Sarawak), Singapore and Indonesia (Sumatra, Nias, Java); *R. nox* Rondani, 1875 is a synonym; records from Sri Lanka and China are errors] *R. lanceolata* Walker, 1856
- Wing cell br without an elongate hyaline streak; cell cu_1 with an isolated anteromedial spot alongside vein Cu_1 [East Malaysia (Sarawak) and Indonesia (Kalimantan: Babidjoelan*)] *R. erebus* Rondani, 1875
- 6 Wing without a distinct hyaline indentation in cell c; cell r_1 with hyaline spot near base absent and indentation at apex of cell sc absent or small and not crossing cell; cell br sometimes with a narrow and indistinct pale

- streak and base of cell r_{4+5} sometimes with a small spot [India, Sri Lanka, Burma, China (Yunnan), Thailand, Philippines (Palawan, Balabac), Malaysia (West, Sarawak) and Indonesia (Sumatra, Java, Kalimantan: Babidjoelan*); *R. quinquemaculata* Bezzi, 1913, **syn. n.**, *R. infirma* Hering, 1941, *R. vittata* Zia, 1963, **syn. n.** and '*R. sexmaculata*' of Hardy (1986) are regarded as synonyms] *R. parvipunctata* de Meijere, 1911, **stat. rev.**
- Wing with distinct hyaline spots or indentations in cells c-sc and in cell r_1 near base and at apex of cell sc, the latter crossing cell 7
 - 7 Wing cell cu_1 with at most an elongate, non-quadrate hyaline indentation at apex of vein A_1+Cu_2 [Burma, China (Yunnan), Thailand, Malaysia (West, Sarawak, Sabah*), Singapore* and Indonesia (Sumatra, Java); *Ptilona sexmaculata* van der Wulp, 1880, **syn. n.** and *R. sumatrana* Enderlein, 1911 are synonyms; Fig. 1] *R. discalis* (Walker, 1861)
 - Wing cell cu_1 with a large quadrate hyaline indentation at apex of vein A_1+Cu_2 that crosses the cell 8
 - 8 Wing with a large hyaline indentation in cell r_{2+3} below apex of vein R_{2+3} and with (females and some males) or without a large hyaline spot at base of cell r_{4+5} near R-M crossvein [southern Philippines (Tawi Tawi, Mindanao); illustrated by Hardy (1970)] *R. megispilota* Hardy, 1970
 - Wing with at most a small hyaline indentation in cell r_{2+3} below apex of vein R_{2+3} and without a large hyaline spot at base of cell r_{4+5} [Philippines (including Mindanao and Tawi Tawi but not Palawan or Balabac); illustrated by Hering (1941)] *R. lucifer* Hering, 1941
 - 9 Wing base largely hyaline; apex of cell r_{4+5} entirely dark; cell r_1 with a large quadrate indentation crossing cell; 2 large discal spots either side of R-M crossvein; single elongate hyaline indentations in cells m and cu_1 , the latter crossing cell; anepisternum without an additional seta; arista long plumose [China (Yunnan)] *Hexamela bipunctata* Zia, 1963
 - Wing base largely dark; apex of cell r_{4+5} largely hyaline or subhyaline, discal spots normally small and subhyaline; cells m and cu_1 usually with 2 and 3 small marginal hyaline indentations respectively (combined and large in *Ectopomyia* males); anepisternum often with an additional dark seta near ventral margin centrally; arista short plumose 10
 - 10 Almost all head setae brown to black; abdomen largely dark but without distinct dark spots; scutum mostly dark (including medially) with pale submedial vittae and a distinct yellow patch between prescutellar setae; scutellum yellow with a pair of submedial dark vittae; wing with apical hyaline indentations in cells r_{2+3} and r_{4+5} large and broadly ovate or subquadrate and with few discal spots; anepisternum with additional seta weak or absent *Ectopomyia* Hardy, 1973 ... 11

- Head setae mostly yellow; abdomen yellow with distinct brown to black spots; scutum and scutellum yellow with or without small dark spots; wing with apical hyaline indentation in cells r_{2+3} small and rounded and that in cell r_{4+5} subquadrate or narrowly hyaline or subhyaline and with numerous hyaline or subhyaline discal spots; anepisternum with additional seta prominent *Hexacinia* Hendel, 1914 ... 12
- 11 Wing veins R_{2+3} and R_{4+5} diverging apically, with the apex of vein R_{2+3} about equidistant between veins R_{4+5} and M at wing margin; cell r_{2+3} with a hyaline central spot near line of R-M crossvein; anepisternum with additional seta absent; sexes dimorphic in wing pattern and male with a large ventral appendage on front femur [China (Yunnan) and Laos]
..... *E. baculigera* Hardy, 1973
- Wing veins R_{2+3} and R_{4+5} almost parallel, with the apex of vein R_{2+3} distinctly closer to vein R_{4+5} than to vein M at wing margin; cell r_{2+3} without a hyaline central spot near line of R-M crossvein; anepisternum with additional seta present; male unknown [West Malaysia; illustrated by Chua 2009] *E. hancocki* Chua, 2009
- 12 Wing cell r_{4+5} with a broad subquadrate hyaline spot at apex not filling cell; antennae brown to black on apical half [India, Sri Lanka, Burma, China (Yunnan), Thailand, Vietnam, West Malaysia, Indonesia (Sumatra) and Brunei (Chua 2002); presence in Philippines (Luzon) requires confirmation: the type locality, Manila, is possibly incorrect; *H. stellata* (Macquart, 1851) (a homonym) and *H. nigroantennata* Hering, 1956 are regarded as synonyms] *H. radiosa* (Rondani, 1868)
- Wing cell r_{4+5} narrowly subhyaline at apex; antennae entirely yellow ... 13
- 13 Wing cell r_1 with 2 hyaline to subhyaline indentations from costa, both crossing cell; discal spots large, consisting mostly of transverse, elongate spots equal or nearly equal to width of cell; scutum and pleura almost entirely pale or with only a few faint brown spots [Philippines (including Palawan)]..... *H. pellucens* Hardy, 1970
- Wing cell r_1 with 2 or 3 hyaline to subhyaline indentations from costa, the medial spot often vestigial or absent; discal spots small, generally rounded and occupying only a fraction of width of cell; scutum and pleura usually with numerous dark brown to black spots [Philippines (including Tawi Tawi but not Palawan), Brunei (Chua 2002), East Malaysia (Sabah), eastern Indonesia (Sulawesi, Maluku, West Papua) and Papua New Guinea (including Bismarck Archipelago: Hancock and Drew 2003 and Bougainville: Hardy 1986); *H. punctifera* (Walker, 1861), **syn. n.**, *H. stigmatoptera* Hendel, 1928, *H. multipunctata* Malloch, 1939, **syn. n.**, *H. flavipunctata* Hering, 1940, **syn. n.** and *H. celebensis* Hering, 1941 are regarded as synonyms; a record from Sumatra (Hardy 1986) appears to be an error] *H. stellipennis* (Walker, 1860)

Discussion

Hexacinia

Acinia marginemaculata Macquart, 1851, described from 'Asia' (Macquart 1851), was placed in *Hexacinia* by Foote (1984) and Norrbom *et al.* (1999), possibly following a suggestion by Bezzi (1913), but its narrow wing and pattern of markings, particularly the numerous (5-6) marginal spots in cell m, suggest it does not belong there. It is possibly a species of *Paracanthella* Hendel (subfamily Tephritinae) but examination of the type is needed to determine its identity and relationships.

Hexacinia palpata Hendel, 1915, from China, Taiwan and far eastern Russia, was retained in that genus by Hardy (1973, 1974) but was included in genus *Hexaptilona* Hering by Zia (1963) and Wang (1998). Together with the closely related *H. hexacinioides* (Hering, 1938) from Burma, it is currently placed in subfamily Blepharoneurinae (Norrbom and Condon 1999).

Specimens referable to both *H. stellipennis* (Walker) and *H. punctifera* (Walker) occur in Sulawesi (Hardy 1959, DLH pers. obs. of BMNH specimens), Borneo (Hardy 1986, Chua 2002) and New Britain (Hancock and Drew 2003) and the two taxa do not appear to be separable. The size of the medial spot in cell r_1 is variable and sometimes vestigial or absent (Hancock and Drew 2003), with a small spot present in the holotype of *H. celebensis* (Hering 1941). The number and intensity of the dark pleural spots also appear to be variable (Hardy 1974). Accordingly, I am treating *H. punctifera* (Walker, 1861), *H. multipunctata* Malloch, 1939 and *H. flavipunctata* Hering, 1940 as new synonyms of *H. stellipennis*, together with the previously synonymised *H. stigmatoptera* Hendel, 1928 and *H. celebensis* Hering, 1941. Whereas the male epandrium and surstyli appear to be relatively longer and more slender in *H. pellucens* Hardy [and even more so in *H. radiosa* (Rondani)] than in *H. stellipennis* and *H. punctifera*, there appear to be no discernible differences between the latter two taxa (Hardy 1974, 1986).

Hardy's (1986) record of *H. stellipennis* from Sumatra, based on specimens allegedly in BMNH, appears to be an error, since no Sumatran specimens of the genus were found there during a visit in 2012 (DLH pers. obs.).

Rioxa

There has been considerable confusion in the literature concerning the nomenclature and identity of *Rioxa sexmaculata* (van der Wulp, 1880). Originally described from Sumatra (van der Wulp 1880), it was regarded as a senior synonym of *R. sumatrana* Enderlein, 1911, also described from Sumatra (Enderlein 1911), by both de Meijere (1914) and Hardy (1974), the latter at least basing his synonymy on examination of the types. Later, however, Hardy (1986) again separated the two taxa, with *R. sumatrana* subsequently placed as a junior synonym of *R. discalis* (Walker, 1861) by Hancock (1998). Hardy (1973, 1986) regarded *R. quinquemaculata* Bezzi,

1913, as a junior synonym of *R. sexmaculata* and appears to have used the former taxon, described from Tenasserim, Burma (Bezzi 1913) as the basis for his 1986 definition of *R. sexmaculata*, incorrectly listing the 'Type ♀' of the latter as in the Zoological Museum, University of Copenhagen. However, he had previously (Hardy 1969) correctly recorded the 'Lectotype ♂' as in the Zoological Museum, University of Amsterdam, so his 1986 concept of *R. sexmaculata* (unlike that in Hardy 1974) appears not to be based upon the types. Indeed, the type series of *R. sexmaculata*, as illustrated by van der Wulp (1881), is clearly synonymous with *R. discalis* and *R. sumatrana*. The apical extension to wing cell bcu is shown incorrectly elongate in van der Wulp's figures 10 and 11 but correctly in his figure 7; the incorrect state was used by Enderlein (1911) to define his new genus *Ptilonina* and separate *R. sexmaculata* from *R. sumatrana*.

Based on Hardy's (1986) concept of *R. sexmaculata*, Hancock and Drew (1995) synonymised *R. parvipunctata* de Meijere, 1911 with it. However, the latter species, originally described from Java (de Meijere 1911) as a variety [subspecies] of *R. sexmaculata*, is recognised here as distinct, with *R. quinque maculata* Bezzi, 1913, *R. infirma* Hering, 1941 and *R. vittata* Zia, 1963 placed as synonyms, two newly so. Hardy (1973) had previously recognised the synonymy of *R. infirma*.

Records of *R. parvipunctata* (as '*R. sexmaculata*') and *R. discalis* (as '*R. sumatrana*') from West Papua, Indonesia and Malaita, Solomon Islands respectively (Hardy 1986) were regarded as errors by Hancock and Drew (2003), the former being the result of a misinterpreted specimen label that actually refers to Soekaboemi, Java. Records of *R. lanceolata* from Sri Lanka and Yunnan, China are also errors, with both based on misidentifications of *R. parvipunctata*. Specimens recorded from Sri Lanka (Hendel 1928) lack the hyaline markings either side of the R-M crossvein, while that from Yunnan (Wang 1998) has a faint pale streak in cell br and a small basal spot in cell r₄₊₅. Similar variation in wing markings was noted from Sri Lanka by Hering (1956, as '*R. infirma*'), while Hancock and Drew (1995) also recorded a Malaysian specimen (as '*R. sexmaculata*') with a small basal spot in cell r₄₊₅.

Two additional species included in *Rioxa* by Norrbom *et al.* (1999), viz. *Trypeta manto* Osten Sacken and *Rioxa vinnula* Hardy, were transferred to *Freyomyia* Hardy, in the *Acanthonevra* complex, by Hancock (2011).

Biogeography

The *Rioxa* complex is almost entirely restricted to South and Southeast Asia, extending as far west as India and Sri Lanka but only as far north as Yunnan Province in southern China. Although well represented in the Philippines, only two species are otherwise known east of Borneo (*Cribrorioxia perforata* and *Hexacinia stellipennis*), with only *H. stellipennis* reaching the island of New Guinea and the Bismarck Archipelago.

Three monotypic genera are known, with limited and peripheral distributions: *Sophiroides* in Sri Lanka, *Cribroriox*a on Sumba in the Lesser Sunda Islands and *Hexamela* in Yunnan, China. All have relatively broad wings with an almost or entirely dark apex to cell r_{4+5} and an often weak or narrow hyaline marginal indentation in cell m. *Cribroriox*a shares with *Riox*a the distinct dark vittae over the scutum and scutellum and an arcuate vein Sc, while *Hexamela* shares with *Hexacinia* the lack of scutal vittae and the mostly yellow head setae with the upper frontals reclinate. The affinities of *Sophiroides* are uncertain but it is possibly an ancestral relict.

Hexacinia, *Ectopomyia* and *Riox*a are centred in SE Asia. Some species of *Hexacinia* and *Riox*a are widespread, with two (*H. radiosa* and *R. parvipunctata*) recorded from India and Sri Lanka to at least Borneo and one (*H. stellipennis*) known from the Philippines and Borneo to Papua New Guinea. *Riox*a *discalis* is known from Burma and Yunnan to Borneo and Java, while *Ectopomyia* has a more restricted distribution, with the two species (*E. baculigera* and *E. hancocki*) known from Yunnan-Laos and West Malaysia respectively. *Riox*a *lanceolata* is known from West Malaysia to Borneo and Java and *R. erebus* is known only from Borneo. Three species (*H. pellucens*, *R. lucifer* and *R. megispilota*) appear to be endemic to the Philippines. All three genera have a distinctly slender epandrium, surstyli and proctiger and a hyaline or subhyaline apex to cell r_{4+5} , best developed in *Riox*a, *Ectopomyia* and *Hexacinia radiosa*.

The spotted pleura, reclinate upper frontal setae and presence of 2 hyaline marginal indentations in cell m and (usually) 3 in cell cu_1 in *Ectopomyia* and *Hexacinia*, plus the presence of a weak anepisternal seta near the ventral margin centrally in *E. hancocki* and the subquadrate shape of the hyaline apical spot in cell r_{4+5} in *H. radiosa*, suggest a close (and possibly sister-group) relationship. *Riox*a differs from the other two genera in scutal and scutellar markings, in having the upper frontal setae incurved and the vanes of the phallapodeme fused into a Y-shaped structure, and from all the other genera in vein Sc reaching the costa at a distinctly acute angle.

Biology

The log-breeding biology of *Riox*a *parvipunctata* is very similar to that seen in the *Dacopsis* and *Acanthonevra* complexes (Permkam and Hancock 1995, Hancock 2013) and the relationship between them and the *Sophira* complex, which uses living bamboo (Hancock 2012), requires further investigation.

Acknowledgements

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A NOTE ON THE STATUS OF A SUPPOSED 'TYPE' OF *THEMARA ENDERLEINI* HERING (DIPTERA: TEPHRITIDAE)

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Abstract

The 'Type ♂' of *Themara enderleini* Hering recorded by Hardy in 1974 and 1986 is found not to belong to the original series. The true Type ♂ and Type ♀ are located in Warsaw.

Discussion

In discussing the status of *Themara enderleini* Hering, 1938, Hancock (2013) noted there was some uncertainty regarding the location of much of Hering's (1938) type series, particularly his 'Type ♂' and 'Type ♀'. Images of *T. enderleini* were provided by Hancock (2013); for comparison, the related *T. hirtipes* Rondani, with well developed 'eye-stalks', is shown in Figure 1.



Fig. 1. *Themara hirtipes*, male from Temburong, Brunei, March 2013. (Photograph © Clyde Wild, Griffith University).

Hardy (1974) recorded the 'Type ♂' as deposited in the Zoological Museum, Berlin (ZMHU), this later corrected (Hardy 1986) to the Senckenberg Deutsches Entomologisches Institut (DEI). However, examinations of the ZMHU and DEI collections (T. Dikow and A. L. Norrbom pers. comm.) confirmed that there are no valid syntypes of *T. enderleini* in either of those collections, although there is a specimen in DEI with the following label data: 'Sumatra / R. Weber Collection / *Themara enderleini* ♂ Hering det. M. Hering 1939 (handwritten except for 'det. M. Hering 193'). Evidently it was seen by Hering only after his description was published and therefore has no status as a type.

Hering's (1938) 'Type ♂' and 'Type ♀' from Soekeranda, Sumatra, are indeed in the Polish Academy of Sciences Museum and Institute of Zoology, Warsaw (PAN) and bear his determination labels (T. Huflejt pers. comm.). These were both designated paralectotypes by Hancock (2013) who, in designating a male from Liangagas as Lectotype, considered all specimens used by Hering (1938) in his description of *T. enderleini* to be part of his type series [*i.e.* syntypes], with none expressly excluded by him (ICZN 1999: Article 72.4.1) and the designation '♂-, ♀- Type' used, rather than the strictly defined term 'types' alone (ICZN 1999: Article 72.4.6).

Acknowledgements

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PSYCHOPSOID NEUROPTERA (PSYCHOPSIDAE, OSMYLOPSYCHOPIDAE) FROM THE QUEENSLAND TRIASSIC

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Abstract

Six species of psychopoid neuropterans are recorded from the southeastern Queensland Late Triassic Blackstone Formation at Denmark Hill and Dinmore, the Late Triassic Mount Crosby Formation at Mount Crosby, and the early Middle Triassic Gayndah Formation at Gayndah. *Triassopsychops superbus* Tillyard (previously known from Denmark Hill, newly recorded from Dinmore) has a suite of apomorphies confirming its earlier placement in Psychopsidae. Additional material of *Osmylpsychops spillerae* Tillyard (type species of the family Osmylpsychopidae) (previously known from Denmark Hill and Mount Crosby, newly recorded from Dinmore) confirms the presence of a recurrent humeral vein and demonstrates its high degree of intra-specific variation in size and venation. *Petropsychops superbus* Riek (previously known from Denmark Hill, newly recorded from Mount Crosby), with M and Rs uniquely structured basally, is retained in Osmylpsychopidae, although its strongly pectinate M is similar to some species of the Mesozoic psychopoid family Kalligrammatidae. *Archeopsychops triassicus* Tillyard (Denmark Hill), possibly conspecific with *O. spillerae*, is known only from its fragmentary holotype and is retained for convenience in Osmylpsychopidae. *Protopsychoptis venosa* Tillyard (Denmark Hill) is known only from its holotype, which is too fragmentary to be considered any more than Neuroptera incertae sedis. The sixth species, *Gayndahpsychops carsburgi* gen. et sp. n., from the early Middle Triassic of Gayndah, is a small osmylopsychopid with CuA extensively pectinate.

Introduction

In the fossil insect literature, the term 'psychopoid' is used for those fossil lacewing species with a suite of wing characters broadly similar to those of the extant Psychopsidae, viz. wing broad, generally no more than twice as long as wide, somewhat triangular, with apical margin truncate; costal space broad, especially in the forewing, with recurrent humeral vein; Sc, R₁ and Rs strongly aligned; venation dense, Rs with numerous, usually closely parallel, pectinate branches. The psychopoid clade is generally considered to comprise four families: the extant and fossil Psychopsidae, and the extinct Mesozoic families Osmylpsychopidae, Brongniartiellidae and Kalligrammatidae (Makarkin *et al.* 2013, and see discussion in Yang *et al.* 2012). The Mesozoic Aetheogrammatidae (Ren and Engel 2008) has also been included, but the placement of this aberrant family remains problematical.

In Australia, fossil psychopoids have previously been recorded from two Triassic localities in southeastern Queensland. Tillyard (1917, 1919, 1922, 1923) described *Protopsychoptis venosa* Tillyard, *Archeopsychops triassica* Tillyard (now *A. triassicus*, see ICZN Article 30.1.4.3), *Triassopsychops superba* Tillyard (now *T. superbus*, ICZN Article 30.1.4.3), and *Osmylpsychops spillerae* Tillyard from the Blackstone Formation at Denmark Hill. Riek (1955) recorded *A. triassicus* and *O. spillerae* from the Mount Crosby Formation at Mount Crosby and, in 1956, described

Petropsychops superba Riek (now *P. superbus*, ICZN Article 30.1.4.3) from Denmark Hill. Both Tillyard and Riek considered *T. superbus* as the oldest true psychopsid and Riek (1955) placed the other four species in his newly established family Osmylpsychopidae, unaware that Martynova had established the same family in 1949 (but as Osmylpsychopsidae, see Makarkin and Archibald 2005).

In recent years, local fossil enthusiast Allan Carsburg has collected many valuable new specimens of fossil psychopsoidea from Mount Crosby and from a different exposure of the Blackstone Formation at Dinmore, also in southeastern Queensland. There is now a second specimen of *T. superbus* (from Dinmore) and a nice series of *O. spillerae* from both Mount Crosby and Dinmore. Additionally, a new psychopsoidea species has been collected by the author from the Middle Triassic Gayndah Formation near Gayndah, again in southeastern Queensland. The availability of this new material has prompted the present review of the Queensland Triassic psychopsoidea fauna. The purpose of the present work, therefore, is to re-examine and, for the first time, provide accurate line drawings of the holotypes of *P. venosa*, *A. triassicus*, *T. superbus*, and *P. superbus*, provide new information on the venation of *O. spillerae* further to Lambkin (1992), describe the new species from Gayndah and discuss the family relationships of the species.

Specimens have been identified as fore- or hind wings by the relative width of the costal space (much wider in forewings) and the convexity or concavity of CuA (convex in forewings, concave in hind wings). Conservative venational nomenclature is used and the view expressed by Makarkin *et al.* (2009) that the radius and media are not fused basally in Neuroptera is adopted. The division of the media into MA and MP is only used where the stem of M has a clear primary dichotomous basal fork with each branch forming a reasonably distinct vein system. All figures are inked line drawings prepared using a camera lucida attachment on a Motic stereomicroscope. To facilitate comparison, all specimens are figured as right wings. Abbreviations for collections are as follows: ACC – Allan Carsburg Collection, Brisbane (to be deposited in QM); GSQ – Geological Survey of Queensland (all specimens now transferred to the QM); QM – Queensland Museum; UQ – University of Queensland (all specimens now transferred to the QM).

The fossil localities

The Denmark Hill fossil lacewings recorded by Tillyard (1917, 1919, 1922, 1923) and Riek (1956) were collected in grey shales of the Late Triassic (Carnian) Blackstone Formation, the uppermost member of the Ipswich Coal Measures (Purdy and Cranfield 2013). The exposure, which is no longer accessible, was in a small quarry in what is now the Denmark Hill Conservation Park (-27.622° 152.756°) in the city of Ipswich. The site was documented in detail by Dunstan (1923).

The Dinmore locality (-27.606° 152.827°), also in the Blackstone Formation, is a small commercial clay pit in Dinmore, a suburb of Ipswich, approximately seven kilometres east of Denmark Hill. The site has been well documented by Rozefelds and Sobbe (1987). The lithology and composition of the insect fauna are more or less identical to those of Denmark Hill.

The Mount Crosby insects occur in green shales of the Mount Crosby Formation and have been collected at five separate exposures designated as Fossil Insect Localities A, B, C, D and E (details in Allen 1961), in the vicinity of Mount Crosby, north of Ipswich. The specimens discussed herein were collected at Localities B (-27.552° 152.782°) and C (-27.550° 152.769°). The Mount Crosby Formation, also dated as Carnian, is the basal sedimentary member of the Ipswich Coal Measures (Purdy and Cranfield 2013). The fossil insects are thus slightly older than those of the Blackstone Formation at Denmark Hill and Dinmore.

The Gayndah species described herein was collected in grey shales of the early (Anisian) Middle Triassic Gayndah Formation (Purdy 2013), in a road cutting (-25.615° 151.640°) approximately three kilometres ENE of the town of Gayndah. A species of the lacewing genus *Lithosmylidia* Riek has also been recorded from the same site (Lambkin 1988).

Systematics

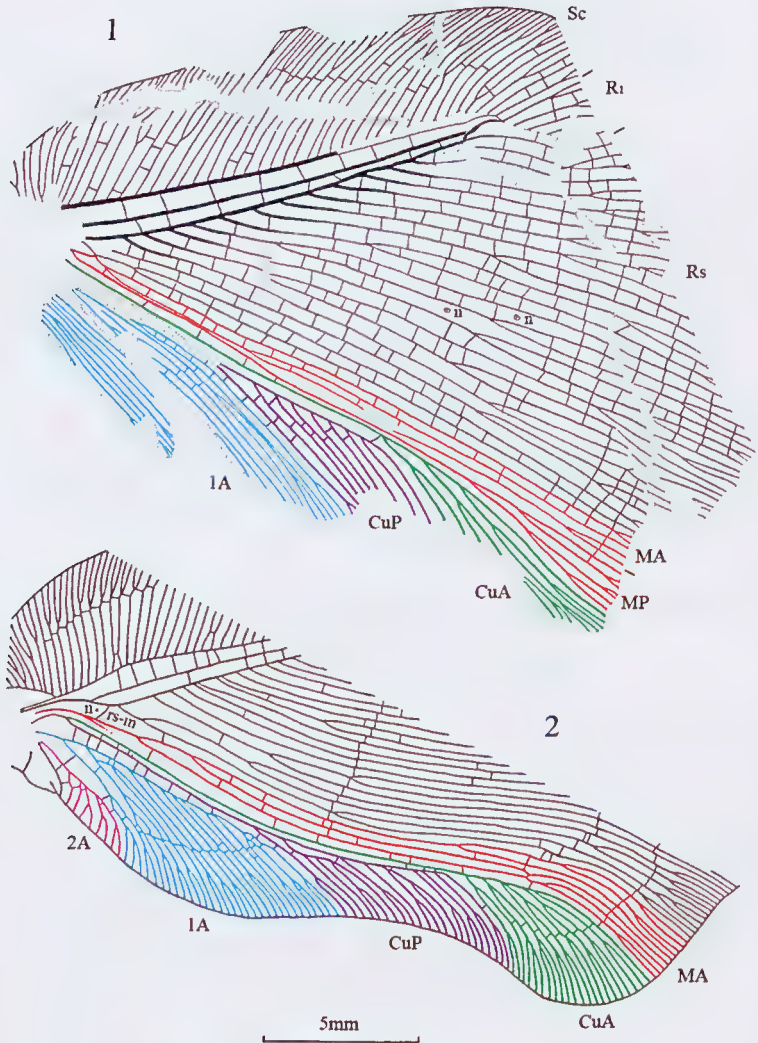
Family Psychopsidae Handlirsch
Triassopsychops superbus Tillyard
(Figs 1, 3)

Triassopsychops superba Tillyard, 1922: 467-469, text-fig. 89, plate 52.

Material examined. *Holotype* GSQ 284a, Denmark Hill, incomplete forewing, part only, length (along Sc) 21 mm, width 21 mm; ACC I.100, Dinmore, Queensland, right forewing fragment, part only, length 14.5 mm, width 15 mm.

Notes. The only previous illustrations of *T. superbus* have been photographs by Tillyard (1922, plate 52) and Jell (2004, p. 84), and a line drawing by Tillyard (1922, text-fig. 89). While Tillyard's photograph is adequate, his line drawing is one of his 'restorations', with much surmise and many inaccuracies and, for some reason, was printed upside down. Jell's new photograph is not all that clear and, apparently based on Tillyard's restoration, is also printed upside down.

Due to the state of preservation the identification of the veins in the M and Cu fields is problematical. This is especially true of the holotype where the wing in this area is broken and over-folded. The bases of both specimens are crushed, with the veins broken and/or artificially approximated. The holotype is flattened and has some veins showing as moulds and some as castes. It has therefore not been possible to determine if it is a left or right wing or make any confident determinations of vein convexities or concavities.



Figs 1-2. Psychopsidae. (1) *Triassopsychops superbus*, holotype GSQ 284a, Denmark Hill. (2) *Psychopsis illidgei*, ♀, Tamborine Mountain, Queensland, in QM, right forewing. *n* nygma; *rs-m* basal crossvein between R_s and M.

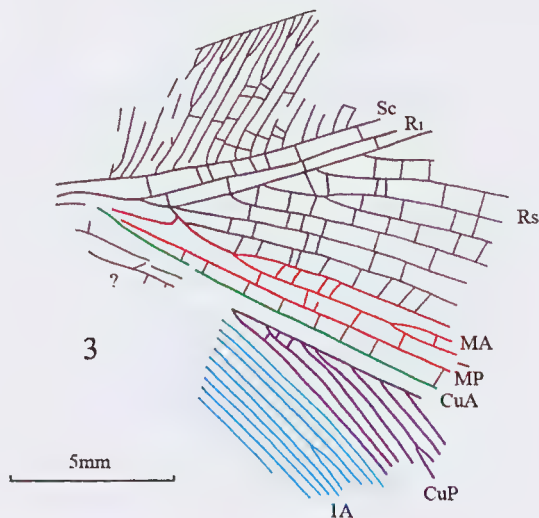


Fig. 3. *Triassopsychops superbis*, ACC I.100, Dinmore.

The venational interpretation herein, therefore, is based on as close as possible examination of the wing bases, the vein convexities or concavities in ACC I.100, and comparison of the relative length and extent of the M and Cu fields with those in the most similar living psychopsid, *Psychopsis illidgei* Froggatt (Fig. 2).

The drawings of the holotype (Fig. 1) and the new Dinmore specimen (Fig. 3) illustrate the following pertinent information about the wing and the venation of *T. superbis*:

1. The angle of the basal subcostal veinlets suggests the presence of a recurrent humeral vein (Fig. 1).
2. No trichosors were detected on the preserved wing margins.
3. The costal space does not taper and is almost as wide apically as it is basally (Fig. 1).
4. The crossveins of the costal space are random basally (Figs 1, 3), although there is a suggestion of an alignment apically in the holotype (Fig. 1).
5. Sc, R₁ and Rs appear to form a true 'vena triplica': strongly aligned, apparently almost parallel and not noticeably convergent apically (although the holotype is not clearly preserved in this area) and braced by crossveins for the entire length (Figs 1, 3).

6. Two nygmata are present in the central radial field (Fig. 1).
7. Most branches of Rs are dichotomously forked within the discal area of the wing (Fig. 1).
8. The radial and medial fields have numerous irregularly spaced crossveins, although there is alignment into gradate series in apical half of sectors in the holotype (Figs 1, 3).
9. M occupies a small area of the central portion of the wing and is dichotomously branched into MA and MP extreme basally, before the origin of Rs (Figs 1, 3).
10. The stem of MA curves antieriad basally and either just touches (Fig. 1), or is fused for a short distance with (Fig. 3), the basal branch of Rs.
11. MA has three long dichotomous branches, simple for most of their lengths (Figs 1, 3).
12. MP is simple to beyond half its length, then dichotomously branched (Figs 1, 3).
13. The space between MP and CuA is braced by numerous crossveins (Fig. 3).
14. The base of CuA in ACC I.100 is convex, although its longitudinal section is neutral. CuA is simple to about half its length, then dichotomously branched.
15. CuP is concave in ACC I.100 and is extensively pectinately branched (Figs 1, 3).
16. 1A is extensively pectinately branched (Figs 1, 3).

I consider that the presence of a uniformly broad costal space, an apparent true '*vena triplica*', the outer radial and medial cross-veins at least partly aligned into gradate series and the richly pectinate CuP and 1A, are all apomorphies of Psychopsidae and provide good evidence that *T. superbis* is indeed the oldest true psychopsid. In this regard, it is worth noting the similarities in these characters to those in the only living species of similar size, *P. illidgei* (Fig. 2). *Triassopsychops superbis*, however, has a suite of plesiomorphies not found in extant psychopsids, viz. the much more randomly placed crossveins, the presence of nygmata in the radial field, the extensive dichotomous branching of the Rs branches within the discal area, the retention of MP as a separate longitudinal vein (only the weakly sclerotised stem remains in *P. illidgei* - see Fig. 2) and the dichotomous branching of CuA. The peculiar up-curving of the stem of MA to touch or fuse for a short distance with the basal branch of Rs is considered an autapomorphy for the genus. In living psychopsids, e.g. *P. illidgei* (Fig. 2), *Psychopsis mimica* Newman, *Psychopsis elegans* (Guérin), *Psychopsis*

barnardi Tillyard, and *Psychopsis insolens* McLachlan (specimens in QM collection; see also New 1988, Oswald 1993) and in the Baltic amber *Propsochopsis lapicidae* MacLeod (MacLeod 1970, fig. 8), the stem of MA does not curve towards the Rs but is joined to its base by an upright or forwardly inclined crossvein (Fig. 2). *Triassopsychops superbis* must have been an impressively large lacewing, with a total forewing length, based on the size of the holotype, of around 30 mm.

Peng *et al.* (2011) listed 35 Mesozoic and Tertiary fossil species that have been ascribed to Psychopsidae and, with additions by Jepson *et al.* (2012) and Makarkin *et al.* (2012), the number now stands at 41. Many of these are fragmentary and/or poorly illustrated, so their relationships thus remain uncertain. Based on the available illustrations, many have similarities with *Osmypsochops* Tillyard, the type genus of the family Osmypsochopidae, and may be more accurately placed in that family. Peng *et al.* (2011) suggested a division of the fossil psychopsids into two groups. The first group, which includes all extant genera as well as five from the Cretaceous and Eocene, has the branches of Rs in the discal field simple, crossveins of the costal space arranged in one or two gradate series and those of the radial field in two to four gradate series. The second group, which includes the remaining Mesozoic species in their list, including *Triassopsychops*, has the branches of Rs in the discal field dichotomously branched and the crossveins of the costal space and the radial field random or at most forming many short, irregular gradate series.

Family Osmypsochopidae Martynova

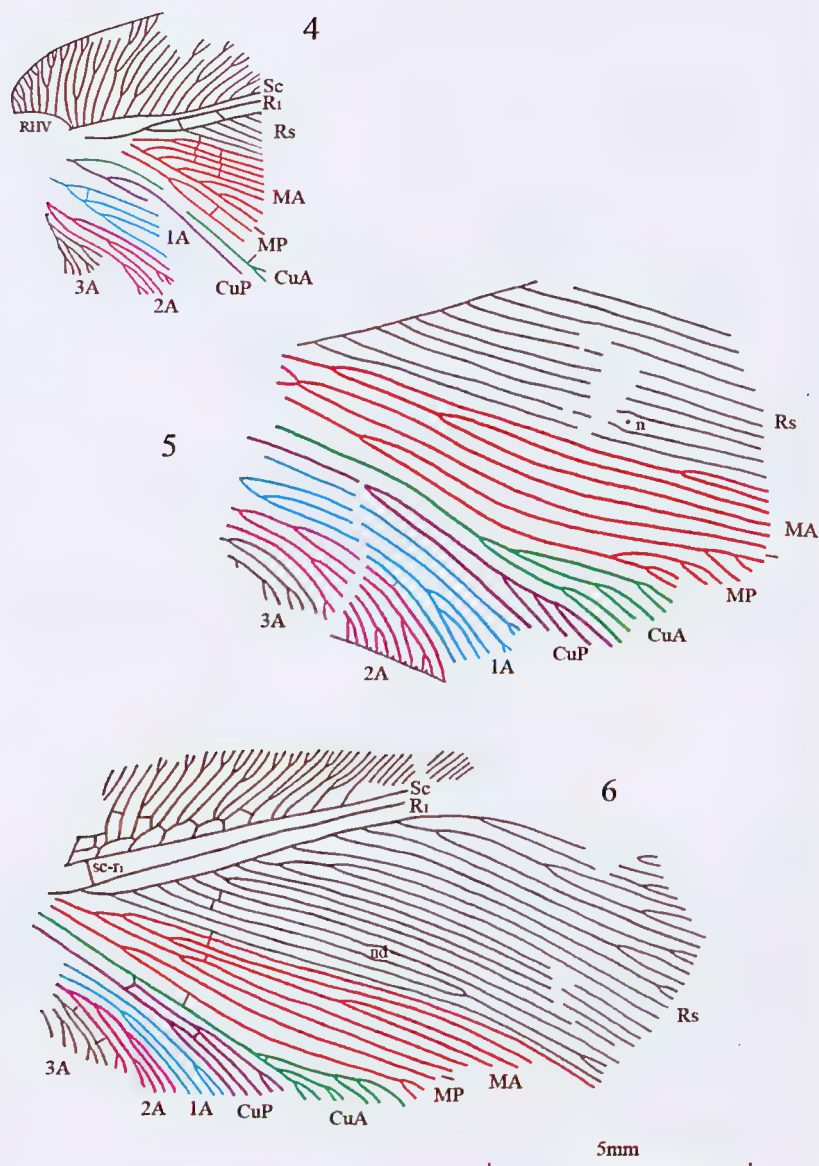
Osmypsochops spillerae Tillyard

(Figs 4-8)

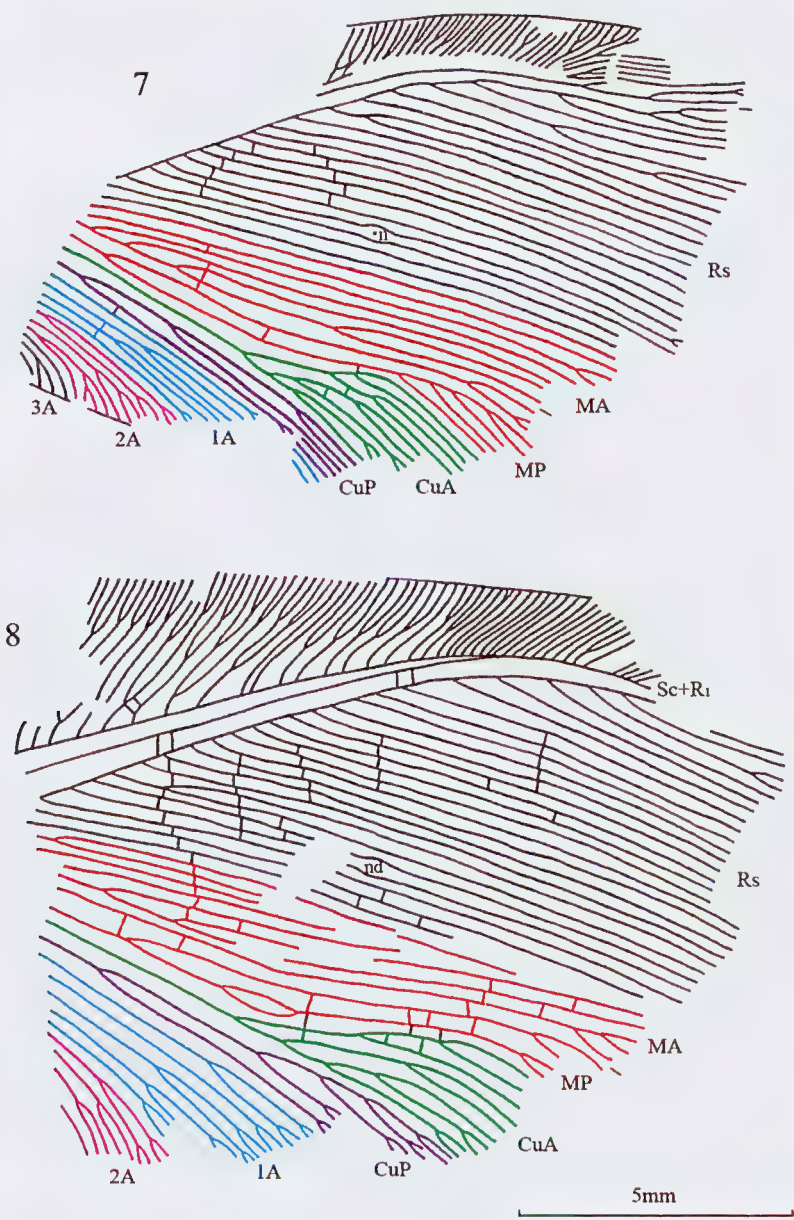
Osmypsochops spillerae Tillyard, 1923: 496-497, text-fig. 93, plate 43.

Material examined. QM F57529, Dinmore, incomplete right forewing, part and counter-part, length 8 mm, width 7 mm; ACC I.101, Dinmore, incomplete right forewing, part only, length 14 mm, width 11.5 mm; QM F57530, Mount Crosby, Locality B, right forewing fragment, part only, collected by K.J. Lambkin, length 10.5 mm, width 7.5 mm; ACC I.102A, B, Mount Crosby, Locality B, incomplete left forewing, part and counter-part, length 12 mm, width 8.5 mm; ACC I.19A, B, Mount Crosby, Locality C, incomplete left forewing, part and counter-part, length 14 mm, width 6.5 mm.

Notes. *Osmypsochops spillerae* is the most frequently collected and best documented lacewing from the Queensland Triassic. In 1992, I reconstructed an almost complete forewing based on several well-preserved specimens from Mount Crosby (Lambkin 1992). There are now five additional forewings, three from Mount Crosby and two from the Dinmore locality of the Blackstone Formation (Figs 4-8), which tell us more about the wing and venation of this species.



Figs 4-6. *Osmylopsychops spillerae*: (4) QM F57529, Dinmore; (5) QM F57530, Mount Crosby; (6) ACC I.19A, B, Mount Crosby. *n* nygma; *nd* dilation of veins suggesting presence of nygma; *RHV* recurrent humeral vein; *sc-r₁* crossvein between Sc and R₁.



Figs 7-8. *Osmylopsychops spillerae*: (7) ACC I.102A, B, Mount Crosby; (8) ACC I.101, Dinmore. *n* nygma; *nd* dilation of veins suggesting presence of nygma.

In all specimens CuA is noticeably convex, which identifies them as forewings. The vein system interpreted as MA is identified as such on the grounds that it has a common basal stem with the system identified as MP, as demonstrated in the clearly preserved specimen illustrated in Lambkin (1992, fig. 6) and also strongly suggested in new specimens QM F57529 and ACC I.19A, B (Figs 4, 6).

QM F57529 (Fig. 4) confirms the presence of a recurrent humeral vein at the base of the costal space, as conjectured by Tillyard (1923, text-fig. 93). This is the first specimen to preserve this area of the wing. The recurrent humeral vein is generally present in both fossil and extant psychopsoids (Makarkin *et al.* 2013) and is clearly present in the only other well enough preserved osmylopsychopid, an undescribed species from the Middle to Late (Ladinian-Carnian) Triassic Madygen Formation of Kyrgyzstan (Shcherbakov 2008, fig. 6; V.N. Makarkin pers. comm.).

The other important information that the new material demonstrates is the degree of intra-specific variation in wing size and venation. Figures 4-8 are all drawn to the same scale and demonstrate the size range of the species, from ACC I.19 (Fig. 6) of width 6.5 mm, to the comparable fragment of ACC I.101 (Fig. 8), almost twice as large at width 11.5 mm. Similar variation also occurs in extant psychopsoids that demonstrate a degree of sexual dimorphism in size, the males being generally smaller than the females. For instance, the good series of specimens of *Psychopsis insolens* in the QM range from forewing length 11 mm and width 6 mm (♂, Toowoomba, Queensland), to forewing length 18 mm and width 11 mm (♀, Killarney, Queensland). The size variation in the QM specimens of the spectacular *Psychopsis illidgei* is equally as stark, ranging from forewing length 23 mm and width 14 mm (♂, Bunya Mountains, Queensland), to forewing length 31 mm and width 20 mm (♀, Tamborine Mountain, Queensland). In many specimens, the size difference is also reflected in the richness of the venation, particularly the number of pectinate branches of Rs. In *P. insolens* these vary from eight in the Toowoomba ♂ to 13 in the Killarney ♀, and in *P. illidgei* from 19 in the Bunya Mountains ♂ to 28 in the Tamborine Mountain ♀.

With regard to the venation, even though the basic pattern is consistent across all specimens (Figs 4-8; Lambkin 1992, figs 3-8), the venational details can vary quite considerably. Much of the variation appears to be related to wing size, with the larger wings generally possessing more vein branches and more bracing cross-veins. Details of the variation are as follows:

1. The crossveins of the costal space may be apparently absent or almost so (Figs 4, 8; Lambkin 1992, fig. 3), sparse in number and forming a simple gradate series (Lambkin 1992, figs 6, 8), or anastomosed with the stems of the subcostal veinlets to form a network running parallel to Sc (Fig. 6; Lambkin 1992, fig. 5).

2. A basal crossvein between Sc and R₁ just beyond the origin of Rs is present in the three specimens where this area of the wing is well preserved (Fig. 6; Lambkin 1992, figs 5, 6). Its apparent absence in QM F57529 (Fig. 4) is considered to be preservation related. No other subcostal crossveins were detected in any of the specimens examined.
3. R₁-Rs crossveins seem to vary in position and angle (Figs 4, 8; Lambkin 1992, fig 5), and were not detected at all in ACC I.19 (Fig. 6).
4. The number of pectinate branches of Rs and the pattern of their dichotomous branching are not the same in any two specimens (Figs 5-8; Lambkin 1992, fig. 5), ranging from approximately 24 branches with only one dichotomously branched in the large ACC I.101 (Fig. 8), to only approximately 14 branches with three of these dichotomously branched in the much smaller ACC I.19 (Fig. 6).
5. A nygma is consistently present between the second and third, third and forth, or forth and fifth branches of Rs, either as a detectable spot (Figs 5, 7; Lambkin 1992, fig. 5), or at least evidenced by a slight dilation of the veins (Figs 6, 8).
6. Crossveins of the radial, medial, cubital and anal fields are generally difficult to detect and are as indicated in Figs 4-8 and the figures in Lambkin (1992); those that have been tentatively detected vary considerably in number and position, from very few (Fig. 5; Lambkin 1992, fig. 5), to more numerous and forming irregular gradate series (Figs 7, 8).
7. The basic branching pattern and shape of M is quite constant, *i.e.* primary forking into MA and MP at the base of the wing, well before the origin of Rs; MA forked close to its origin and multi-branched, occupying a large area in the centre of the wing; MP forked dichotomously well beyond the primary fork of MA, the branches parallel, somewhat sinuous, and simple for most of their length. The number and pattern of branching of MA, however, varies considerably, from simply dichotomous with six major branches (Figs 5, 6), to strongly pectinate with as many as six anteriorly-directed branches mirroring the pectination Rs (Figs 4, 7). The only variation in MP is the presence in some specimens of an enclosed cell on MP₃₊₄ (Fig. 8; Lambkin 1992, fig 3).
8. The pattern of Cu is fairly constant. CuA is simple and straight for much of its length, but then curved antieriad and forked into eight or nine branches to form a broad, somewhat triangular area apically (Figs 7, 8; Lambkin 1992, fig. 5). CuP forks earlier than CuA, about at the level of the primary fork of MP (Figs 5-8; Lambkin 1992, fig 6) or more basally (Fig. 4) and the subsequent branching is a little variable (Figs 5-8; Lambkin 1992, figs 3, 5).

9. The anal area of the wing is incomplete in most specimens and the identification of 1A, 2A and 3A in Figs 5-8 is a best estimate based on the pattern in QM F57529 (Fig. 4) and in the wing base illustrated in Lambkin (1992, fig. 6). Comparison of the figures again indicates a consistent pattern of dichotomous branching, but with variation in the details of the more apical branching of the veins.

In summary, the new specimens recorded herein further augment our knowledge of the wing and venation of *O. spillerae*, making it one of the best documented fossil lacewings. The degree of intra-specific variation is of particular note as a cautionary guide to the proliferation of species names for fossil Neuroptera based only on trivial venational differences.

Petropsychops superbis Riek

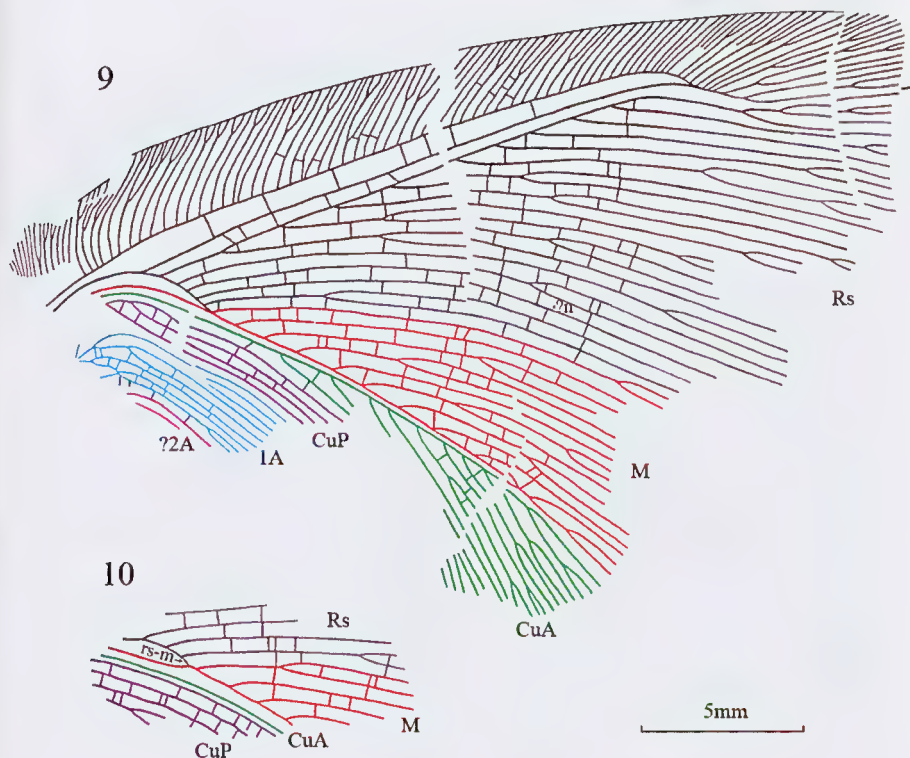
(Figs 9-10)

Petropsychops superba Riek, 1956: 104-105, fig. 2.

Material examined. Holotype UQ C2135-6, Denmark Hill, incomplete left forewing, part and counterpart, length 28 mm, width 18 mm; QM F57531, Mount Crosby, Locality B, left forewing fragment, part and counterpart, collected by K. J. Lambkin, length 10.5 mm, width 4 mm.

Notes. This species, previously known only from the holotype specimen collected at Denmark Hill, is now also recorded (QM F57531) from the slightly older Mount Crosby Formation. The only previous illustrations of *P. superbis* have been photographs by Riek (1956, fig. 2), Jell (2004, p. 83) and Grimaldi and Engel (2005, 9.15). The drawings of the holotype (Fig. 9) and the new Mount Crosby specimen (Fig. 10) presented herein illustrate the following pertinent information about the wing and the venation of *P. superbis*:

1. The angle of the basal subcostal veinlets suggests the presence of a recurrent humeral vein (Fig. 9).
2. No trichosors were detected on the preserved wing margins.
3. The costal space tapers to be almost as half as wide apically as it is basally (Fig. 9).
4. The crossveins of the costal space are few in number and not arranged into gradate series (Fig. 9).
5. SC, R₁ and Rs are more or less parallel for their entire lengths, but with the apex of Sc curved posteriad to fuse with R₁. There are several randomly placed crossveins (Fig. 9).
6. Most of the branches of Rs are dichotomously forked within the discal area of the wing (Fig. 9).



Figs 9-10. *Petropsychoops superbis*: (9) holotype UQ C2135-6, Denmark Hill; (10) QM F57531, Mount Crosby. *n* nygma; *rs-m* basal crossvein between Rs and M.

7. There is a raised spot which may be a nygma between the 2nd and 3rd branches of Rs (Fig 9). It is, however, not clearly preserved and is not centred between the veins as nygmata usually are.
8. The proximal radial and medial fields have numerous randomly spaced crossveins, but none is present beyond the level of the apex of Sc (Fig. 9).
9. The first branch of Rs (Rs₁) and the stem of M form a peculiar structure at the base of the wing, interpreted as follows: Rs₁ curves posteriad just beyond the origin of Rs, throws off three or four pectinate branches parallel with the remaining branches of Rs and those of M, and is then connected to the stem of M by a short, oblique crossvein (*rs-m* in Fig. 10) that appears to be a continuation of Rs₁. An alternative interpretation of the structure is that the system identified as Rs₁ is indeed a multi-branched MA formed by the sharp recurving of the stem of MA (*rs-m* in

the interpretation above), which then throws off four pectinate branches and is joined to the base of Rs by a short Rs-MA crossvein.

10. The stem of M is strongly concave and has at least 11 anteriorly-directed pectinate branches, mostly dichotomously forked, which parallel those of Rs. M thus occupies a considerable area of the centre of the wing (Fig. 9).
11. The stem of CuA is strongly convex, runs very closely and parallel with the stem of M and has numerous, mostly dichotomously forked, pectinate branches that almost precisely mirror those of M (Fig. 9).
12. CuP is deeply dichotomously forked with four or five main branches and numerous crossveins (Figs 9, 10).
13. 1A is deeply dichotomously forked, with approximately nine main branches and numerous crossveins (Fig. 9).

Petropsychops superbus, as its species name alludes, must have been a superbly impressive lacewing with a total forewing length, judging by the size of the holotype, of just over 30 mm. The peculiar structure of Rs₁ and the stem of M appears to be unique among Neuroptera and is a strong autapomorphy for the genus. The relationship of *Petropsychops* to other psychopsoidea, however, remains problematical. As noted by Riek (1956), the strong anterior pectination of M is a characteristic of some genera of Kalligrammatidae, the psychopsoidea family considered by Makarkin *et al.* (2009) as the sister group of Osmylepsychoidea. Indeed, the similarity of both M and CuA in *P. superbus* to those veins in the recently described kalligrammatid *Apochrysogramma rotundum* Yang, Makarkin and Ren is striking (see Yang *et al.* 2011, fig. 5). *P. superbus*, however, lacks the very characteristic remigial 'eye' spot and extremely dense crossvenation of Kalligrammatidae (Ren and Engel 2008). On these grounds, as well as its similarity to *Osmylepsychoidea*, which, as demonstrated herein, also shows a tendency to the anterior pectination of at least MA (Figs 4, 7), it is considered that, for the present, *Petropsychops* is best retained in Osmylepsychoidea. The difficulty of its family placement again emphasises the issue raised by many authors (*e.g.* Makarkin 2010, Peng *et al.* 2010, Peng *et al.* 2011) of the need for a comprehensive analysis of the family classification of the Mesozoic psychopsoidea, which as a result of the many recent discoveries are now known to be highly diverse and species-rich (see lists in Yang *et al.* 2009, and Peng *et al.* 2011).

Archeopsychoidea triassicus Tillyard

(Fig. 11)

Archeopsychoidea triassica Tillyard, 1919: 205-211, text-fig. 27.

Material examined. Holotype GSQ 137a, Denmark Hill, right forewing fragment, part only, length 7 mm, width 6.5 mm.

Notes. Tillyard's text figure is again somewhat of a 'restoration' and contains more veins than the specimen actually possesses. The only other previous illustration of the specimen is the photograph in Jell (2004, p. 83). The new drawing (Fig. 11) of *A. triassicus* demonstrates the fragmentary nature of its type specimen, which is a cast with both R_1 and CuA strongly convex thus indicating a forewing. The vein labelled Cu by Tillyard is actually a deep groove in the wing and not a vein.

Riek (1955) placed *A. triassicus* in the Osmylpsychopidae and suggested that *O. spillerae* might be its junior synonym. Indeed, the very fragmentary specimen from Mount Crosby (UQ C679), which Riek tentatively referred to *A. triassicus*, is in fact a wing base fragment of *O. spillerae* showing the anal veins and multi-branched MA similar to those illustrated in Lambkin (1992, fig. 2). Although it is quite likely that *A. triassicus* and *O. spillerae* are indeed the same species (compare Fig. 11 with Figs 4-8 and the figures in Lambkin 1992), due to the fragmentary nature of the type of *A. triassicus* it would be unwise to synonymise the very well documented *O. spillerae* with it. It also remains possible that *A. triassicus* is indeed distinct. As indicated in Fig. 11 it does have at least four crossveins between Sc and R_1 , whereas no specimen of *O. spillerae* has been found with more than one. The vein interpreted as CuP is much more deeply forked than in most specimens of *O. spillerae* but, as listed above, the level of this forking in *O. spillerae* is variable and the level in *A. triassicus* is the same as that in *O. spillerae* specimen QM F57529 (Fig. 4).

Genus *Gayndahpsychops* gen. n.

Type species *Gayndahpsychops carsburgi* sp. n.

Diagnosis. Forewing. Relatively small size, width approximately 7.5 mm; M occupying a large area in centre of wing; MA with two deep dichotomous forks at level of origin of Rs; MA_1 fused with the apparent posterior branch of Rs_1 , this fused vein then fused with the apparent anterior branch of Rs_1 ; MP simple for about half its length, then dichotomously forked; CuA with seven long posteriorly-directed pectinate branches which occupy a large area of the wing; CuP deeply dichotomously forked basal to the origin of Rs, each branch simple for most of its length.

Etymology. The generic name recognises the locality of the type species, the Gayndah Formation at Gayndah in southeastern Queensland.

Notes. *Gayndahpsychops* is placed in Osmylpsychopidae because of its basic psychopsoid facies, its small size, lack of well defined gradate crossvein series, lack of extremely dense crossvenation and an eye-spot and, most importantly, the extensive nature of M, which I consider is synapomorphic with the type genus of the family, *Osmylpsychops*. It differs

from *Osmylepsychops* in the complex fusions of MA_1 and Rs_1 (these veins are not connected in any of the many specimens of *O. spillerae*), the much more apically forked MP (forked just beyond origin of Rs in *Osmylepsychops*), the richly pectinate CuA, which occupies a large area of the wing (dichotomously forked and much less extensive in *Osmylepsychops*) and the deep dichotomous forking of CuP with the two branches simple for most of their length (mostly forked at about half length in *Osmylepsychops*, with CuP₁ deeply dichotomously forked). Beyond the type genus, the generic composition and limits of Osmylepsychopidae are poorly known. Other psychopoid genera that have been ascribed to Osmylepsychopidae, e.g. *Actinophlebia* Handlirsch, *Parhemerobius* Bode (Makarkin and Archibald 2005), are not well enough documented to allow reliable comparison with *Gayndahpsychops*. It is of interest to note, however, that the undescribed osmylepsychopid from the Triassic Madygen Formation illustrated by Shcherbakov (2008, fig. 6) also seems to have CuA posteriorly pectinate.

***Gayndahpsychops carsburgi* sp. n.**

(Fig. 12)

Type and only specimen. Holotype, QM F57532, Gayndah fossil insect locality, incomplete right forewing, part and counterpart, collected by K.J. Lambkin, length 11.5 mm, width 7.5 mm.

Description. Forewing. Subcostal veinlets strongly inclined, dichotomously forked with at least two connecting crossveins; a basal Sc- R_1 crossvein not detected (wing not well preserved in this area); R_1 strongly convex; one R_1 - Rs crossvein detected; Rs richly pectinate, the basal two branches apparently dichotomously forked, the other eight preserved branches simple at least basally; four randomly placed crossveins detected in Rs field; nygma not detected, but a small dilation in the 3rd and 4th apparent Rs branches suggests its presence; stem of M not preserved; one basal crossvein between MA_2 and MA_3 ; MA_4 dichotomously forked with at least seven marginal branches; MP fused with CuA for a short length, with six long apical branches; several randomly placed crossveins in the area of the forkings of MP; CuA strongly convex; one basal crossvein between CuA and CuP₁; at least five of the pectinate branches of CuA dichotomously forked; anal veins apparently quite extensive and dichotomously forked (the notional identification of 1A, 2A and 3A in Fig. 12 based on the pattern in *O. spillerae*); trichosors not detected.

Etymology. Named in honour of Mr Allan Carsburg who collected most of the specimens which made this study possible.

Formation and Age. Gayndah Formation, early (Anisian) Middle Triassic.



Figs 11-13. (11) *Archeopsychops triassicus*, holotype GSQ 137a, Denmark Hill. (12) *Gayndahpsychops carsburgi*, holotype QM F57532, Gayndah. (13) *Protopsychopsis venosa*, holotype GSQ 160a, Denmark Hill. nd dilation in veins suggesting presence of nygma.

Neuroptera *incertae sedis*
Protopsyropsis venosa Tillyard

(Fig. 13)

Protopsyropsis venosa Tillyard, 1917: 178-180, plate VIII, fig. 3.

Material examined. Holotype GSQ 160a, Denmark Hill, wing fragment, part only, length 9 mm, width 7 mm.

Notes. Tillyard's figure is a line drawing and there is also a photograph of the holotype in Jell (2004, p. 83). As Fig. 13 demonstrates, the species is based on a specimen preserving only the apex of a wing that is too fragmentary to warrant further consideration. The only point of note is that the numerous crossveins illustrated in Tillyard's figure could not be detected in the specimen. For the sake of convenience, Riek (1956) placed the species in Osmyllopsychopidae; however, it is simply too fragmentary for even tentative family placement and is thus designated Neuroptera *incertae sedis*.

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